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Journal of Educational Theory and Practice

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Research on the Construction of Computer Professional Clusters and Teaching Reform under the Guidance of the “Double High Plan”

Zhiqiang Zhang^{1*}, Zhenmei Yang²

1. School of Artificial Intelligence, Zhejiang Dongfang Polytechnic, Wenzhou, Zhejiang, 325000, China

2. Wenzhou Polytechnic, Wenzhou, Zhejiang, 325000, China

*Corresponding author: Zhiqiang Zhang

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Abstract: Against the backdrop of accelerating global informatization and intelligence, computer technology has become the key driver of digital transformation across industries, carrying strategic significance for enhancing national competitiveness and promoting high-quality economic and social development. The implementation of the “Double High Plan” marks the transition of China’s vocational education from quantitative expansion to connotative quality improvement. As a professional cluster highly aligned with information technology and the digital economy, computer-related disciplines have naturally become the core cluster in the implementation of the “Double High Plan.” This study, grounded in system theory and competency-based education, systematically analyzes the strategic positioning and historical implications of the “Double High Plan.” By reviewing the theoretical foundations of computer professional cluster construction and analyzing its framework, it innovatively proposes integrative pathways for systemic reconstruction of the teaching system, deep integration of industry and education, and the collaborative construction of institutional safeguards and cultural ecology. These reforms provide theoretical support and practical approaches for the high-quality development of vocational education, holding significant theoretical and practical value in aligning talent cultivation with industrial needs and serving the construction of a digital society.

Keywords: Double High Plan; Computer Professional Cluster; Teaching Reform; Vocational Education; High-Quality Development

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Introduction

The world is currently undergoing profound changes centered on informatization and intelligence. The rapid rise of the digital economy, artificial intelligence, big data, and the Internet of Things is reshaping production and lifestyles in all aspects. In this historical process, computer science and technology have transcended traditional disciplinary boundaries to become the core technology driving digital transformation across industries. With rapid iterations, wide applications, and strong cross-domain integration, it profoundly influences a nation’s strategic initiative and discourse power in global competition, and serves as a key factor supporting high-quality economic and social development.

Vocational education, as an important bridge linking the education chain and talent chain, bears the strategic mission

of supplying highly skilled technical talents for industrial transformation and upgrading. In April 2019, the Ministry of Education and the Ministry of Finance jointly issued the Opinions on Implementing the Chinese Characteristics High-Level Vocational School and Professional Construction Plan (hereinafter referred to as the “Double High Plan”). The document emphasizes establishing new development concepts, serving the modernization of the economic system and higher-quality employment, and supporting the priority development of high-quality vocational schools and professional clusters to lead vocational education in serving national strategies, integrating regional development, and promoting industrial upgrading^[1].

The implementation of the “Double High Plan” signifies a fundamental shift in the development paradigm of vocational education in China—from scale expansion toward connotative quality improvement and characteristic development. The plan not only requires a systematic elevation of schools’ overall level but also stresses leveraging the demonstration role of high-level professional clusters to form replicable and scalable experiences. As a cluster highly consistent with emerging information technology and the digital economy, computer-related disciplines are naturally the core carriers of the “Double High Plan.”

However, challenges remain in computer cluster construction: insufficient alignment between professional layout and industrial structure, outdated course content far behind technological frontiers, weak synergy between teaching innovation and practical skills cultivation, mismatches between faculty’s industry experience and teaching abilities, and limited depth and breadth of industry-education integration. Under the strategic guidance of the “Double High Plan,” addressing these problems systematically to build an organic ecology of cluster construction and teaching reform—achieving precise alignment between talent cultivation and industrial demand—has become a key issue in promoting the high-quality development of vocational education.

1.Strategic Positioning and Value Implications of the “Double High Plan”

1.1 Historical Evolution and Policy Drivers

The “Double High Plan” is not an isolated policy initiative but the inevitable result of the long-term development of vocational education, shaped by practice and historical demands. At the macro level, it responds to the structural demand for highly skilled talents arising from the upgrading of the national economic structure, providing human capital for building a modern industrial system. From a meso perspective, it aligns with the internal law of vocational education’s transformation from scale expansion to connotative development, shifting growth from quantity to quality. From a micro perspective, it addresses long-standing issues such as fragmented professional layouts, single-layered talent cultivation, and weak industry-education integration, providing strategic guidance for systematically reconstructing the vocational education ecosystem. This multidimensional context highlights the systematic thinking and forward-looking nature of the policy.

1.2 Strategic Positioning and Connotation

The core value of the “Double High Plan” lies in cultivating high-level professional clusters with exemplary and leading effects, thereby forming transferable and replicable construction models to elevate the overall quality of vocational education. The key to this positioning is that cluster construction has transcended the superficial combination of individual disciplines. Instead, through systematic design and structural optimization, it creates an organic whole—internally coherent, resource-efficient, and closely aligned with industrial chain dynamics and technological frontiers. Its essence is the reorganization and functional coupling of internal elements to achieve deep integration of the education and talent chains. This not only enhances the precision and adaptability of talent cultivation but also provides institutional support for the sustainable development of vocational education.

1.3 Value Implications and Multidimensional Orientation

For computer clusters, the value implications of the “Double High Plan” have theoretical depth and practical orientation:

Strategic Value: Directly linked to the core of the national digitalization strategy and critical areas of information security, its construction is crucial for safeguarding national sovereignty and driving the digital economy’s high-quality development.

Pioneering Value: Owing to rapid technological iteration and innovation, the computer field leads vocational education reforms, driving systematic reconstruction of teaching philosophy, curricula, and practice, and serving as a reference model

for other disciplines.

Radiative Value: With its cross-domain penetration and ecological integration, computer cluster development promotes synergy across related technical domains and internal linkage among vocational clusters, generating “point-to-surface” ecological effects. This fosters the education system’s evolution toward higher-level collaboration and intelligence.

Together, these values make computer clusters an indispensable hub in the “Double High Plan.”

2.Theoretical Foundations and Logical Framework of Computer Cluster Construction

2.1 Theoretical Foundations

Computer cluster construction is grounded in industrial cluster theory, educational ecology theory, and conjugate synergy theory.

Industrial cluster theory, first proposed by Marshall^[2] and refined by Michael Porter in *The Competitive Advantage of Nations*, stresses aggregating enterprises, institutions, and universities around key industries to enhance competitiveness through resource sharing and specialization^[3].

Educational ecology theory, derived from Bronfenbrenner’s ecosystem theory and extended by Ashby’s concept of “higher education ecology,”^[4] views education as an organic whole with integrity, balance, and sustainability, emphasizing “ecological factors” such as faculty, training bases, and talent cultivation schemes.

Conjugate synergy theory, originating in chemistry and mathematics, highlights how elements form “conjugate relationships” and drive systemic stability^[5]. In computer clusters, disciplines form communities of interest through conjugate structures in faculty, common courses, and school-enterprise projects. Resource competition coexists with flow and sharing, creating internal cohesion and promoting spiral development.

Together, these three theories provide multidimensional support for high-quality and sustainable cluster construction.

2.2 Dynamic Evolution of Cluster Structures and Logical Linkages

Cluster construction must transcend traditional disciplinary boundaries, building a dynamic “foundation–core–expansion” structure. Foundation disciplines provide theoretical bases; core disciplines focus on cultivating key competencies for competitive advantage; expansion disciplines adapt to technological advances and industrial demand shifts.

Integration of the knowledge chain, technology chain, and industrial chain is essential: curricula ensure coherence of learning paths, practice-based design supports skill progression, and job demands guide content relevance. Their organic integration dissolves the gap between theory and practice, creating a closed-loop interaction between education and industry, enabling co-evolution of knowledge, technology, and industrial needs.

2.3 Institutional Innovation in Governance and Synergy

Effective cluster operation relies on institutionalized governance innovation. A governance framework centered on professional clusters should break down departmental silos, create clear accountability, and promote synergy. Resource integration must enhance teaching, research, and industry collaboration, while responsibility-sharing ensures joint participation in quality monitoring and innovation. Such governance transforms clusters from static organizations into dynamic ecosystems, making them hubs of innovation and collaboration that support deep integration of education, talent, and industry chains.

3.Integrated Pathways for Teaching Reform and Safeguard Mechanisms

3.1 Systemic Reconstruction of the Teaching System

Reform should build a competency-oriented teaching system. Course content must overcome fragmentation and repetition by aligning dynamically with technological and industrial changes, forming a progressive logic of “foundation–expansion–integration–innovation.” Teaching methods must shift from one-way transmission to interactive, project-based, task-driven, and problem-solving models, enabling students to construct knowledge and develop abilities in real or simulated contexts. Evaluation should expand beyond exams to include formative, outcome-based, and holistic measures, reflecting development in application, operations, and professionalism. This systemic reconstruction transforms the paradigm from knowledge transmission to capability generation.

3.2 Deep Synergy in Industry-Education Integration

Deep integration requires aligning education and industry chains dynamically. Course content must synchronize with industry standards, supported by advanced training bases and flexible mechanisms^[6]. School-enterprise collaboration should drive co-development of teaching and R&D. Virtual simulation technologies enhance immersive practice experiences, overcoming spatial-temporal limits and enabling complex technical training. Beyond course alignment, institutional platforms should promote enterprise participation in teaching design and resource development, forming ecosystems of co-research, co-standardization, and co-sharing. This shift moves education from closed instruction to open co-creation, dynamically matching talent cultivation with industry needs.

3.3 System Construction of Institutional Safeguards and Cultural Ecology

Sustainable reform requires institutional and cultural support. A full-chain safeguard system should include:

Policy guidance: Linking top-level design with grassroots implementation;

Quality monitoring: Establishing closed-loop systems for curriculum development, teaching implementation, feedback, and improvement;

Cultural immersion: Cultivating a campus culture of skill respect, innovation, and excellence to stimulate intrinsic motivation;

Faculty development: Building teacher communities, providing systematic training, and enhancing integration ability and industry literacy.

This dual construction of institution and culture transforms reform from external drives to self-sustaining evolution, ensuring sustainable quality improvement.

Conclusion

The “Double High Plan” provides institutional support for computer cluster construction and teaching reform, marking a new stage of systemic and high-quality development of vocational education. Under this background, computer cluster construction must adopt systemic thinking, strengthen alignment between curricula and industry demand, drive innovative transformation of teaching models, and emphasize faculty professionalism and industry practice. By building collaborative safeguards of policy, culture, and mechanisms, deep integration of education, talent, and industry chains can be achieved, ensuring sustainable cluster development.

Looking ahead, computer clusters will integrate deeply with AI and big data, driving personalized and intelligent learning with precise evaluation systems. Expanding international cooperation will align with the global vocational education community, drawing on advanced experience to cultivate cross-cultural, versatile talents. Furthermore, embedding green computing and information ethics into training will foster awareness of sustainability and responsibility, producing high-quality technical talents with both innovation and social commitment. Ultimately, cluster development will achieve collaborative progress across intelligence, internationalization, and sustainability.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

Reference

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Evaluating Dual Project-Based Learning Approaches in Vocational Education: Evidence from a Parallel-Class Experiment in a Data Analysis Course

Qiuyang Li, Hanhui Yin, Qianqian Bao, Shiguo Bu, Chen Chen, Siyuan Li*

Yunnan Vocational College of Agriculture, Kunming Yunnan, 650300, China

*Corresponding author: Siyuan Li, 835440260@qq.com

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Abstract: To improve the practical teaching effect of the data analysis course, this study innovatively adopted a three-group parallel class experiment to explore the differences in the impact of personal project-based, team project-based, and traditional teaching. This study used the “Data Analysis Foundation” course at a vocational college as a scenario, implemented teaching interventions on three classes with similar foundations, and evaluated the results through project outcome scoring, practical exam scores, and final exam scores. By comparing project results, practical skills, and theoretical assessments, we found that project-based teaching can significantly improve students’ practical abilities. However, the two modes have different strengths: team projects are better for developing the ability to solve complex problems, while individual projects are better for mastering basic skills. Theoretical knowledge is not affected by the teaching mode. The study shows that project-based teaching is an effective way to strengthen data analysis skills. Among the two modes, the individual mode is better for training basic skills, while the team mode is better for solving complex problems. It is recommended that the course reform design be flexible in selecting the dual mode path according to the training goals.

Keywords: Higher Vocational Education; Teaching Reform; Practice Teaching; Project-Based Learning

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1.Introduction

As big data technology becomes more deeply embedded in various industries, the ability to analyze data has gradually become one of the core professional qualities of high vocational school business and trade talent. As a key course in developing this ability, the importance of the “Data Analysis Fundamentals” course is increasingly apparent. Through research, it was found that the teaching model of this course is currently widely adopted as “theory teaching+distributed experiment,” but the limitations of this teaching model are gradually becoming apparent as the times change^[1]. The main limitations are as follows:

Skills training is inadequate. Students passively complete fragmented exercises and lack training in the complete data analysis process (problem definition, data processing, model building, and decision output), which leads to their inability to handle real business data^[2].

(2) Students’ interest is not stimulated by abstract theories and isolated practices, which leads to low classroom participation and weak high-level analytical skills^[3].

(3) The evaluation criteria are limited. Currently, the evaluation of this course is mainly reflected in the final written exam, which ignores the quantitative assessment of practical skills such as data cleaning, modeling, and visualization^[4].

In response to the aforementioned issues, project-based learning (PBL) has gradually been introduced into the reform of data analysis courses in recent years^{[5][11][12]}. This model drives students through full-process practical experiences via real-world scenario tasks, aligning with the vocational education principle of “learning by doing”^{[5][8][9]}. Previous studies indicate that research on the teaching effectiveness of PBL has predominantly focused on qualitative, single-course investigations. While some researchers have begun attempting quantitative analyses, these studies remain limited in scope. They primarily examine issues identified during the implementation of PBL within a specific course and propose improvements, without establishing consistent methodological approaches^[10]. Crucially, there is a lack of evaluation methods specifically designed to assess the actual teaching outcomes.

Moreover, the current implementation of this course reform faces two major blind spots^[13]. First, the choice of teaching model remains ambiguous, as there is a lack of empirical evidence to determine whether individual independent practice or team collaboration projects within the course are more effective, leading to a certain degree of arbitrariness in instructional design^[6]. Second, the validation of outcomes remains rudimentary. Current practice evaluations are largely confined to qualitative summaries of individual classes or comparisons between a single class’s current status and its past performance. These studies lack quantitative comparisons with contemporaneous control groups, making it difficult to isolate the influence of confounding factors^[7].

Due to the scarcity of quantitative analysis methods and research in previous studies, coupled with the lack of a systematic research methodology^{[1][14]}, there has been a shortage of unified approaches and quantitative methods for evaluating the effectiveness of project-based teaching. Taking the required course “Data Analysis” in vocational colleges’ commerce-related majors such as E-commerce and Supply Chain Operations as an example, this paper proposes constructing a multidimensional quantitative evaluation framework integrating project outcome scoring (process-oriented), practical assessment (skills-based), and theoretical testing (cognitive-based) indicators. This approach breaks through the limitations of traditional single-assessment methods by employing mature statistical comparison techniques to provide quantifiable evaluation methods. It evaluates the pilot effectiveness of the project-based teaching model within this course. Furthermore, drawing from the case study and analysis process, this paper attempts to propose a universal approach and quantitative analytical method for evaluating the teaching effectiveness of this model.

2. Teaching Practice Research Design

2.1 Research Subjects and Grouping

To scientifically compare the effectiveness of different teaching models, this study selected three parallel classes (Class 1, Class 2, and Class 3) enrolled in the same grade’s “Fundamentals of Data Analysis” course at our institution. Students across all three classes possessed comparable foundational proficiency (no significant differences in entrance math scores or prerequisite course grades), and class assignments were determined by random student ID number sequencing. Consequently, student learning profiles were nearly identical with no discernible variations. Specific grouping arrangements are as follows:

Class A employs individual project-based instruction, where students independently complete three practical projects such as backend data cleansing, user behavior visualization, and seasonal sales forecasting. Class B employed team-project-based instruction, where groups of 3-4 students collaboratively completed an integrated project (e.g., annual operational analysis of an e-commerce platform), covering the entire process from data collection to decision-making recommendations. Class C served as the control group, continuing the traditional lecture-plus-laboratory model. After explaining key concepts, the instructor guided students through practical exercises organized by chapter.

The key control points of the study are that all three classes are taught by the same instructor, using identical textbooks, core knowledge points, and theoretical course content. Only the practical components differ in design.

2.2 Teaching Implementation Process

First, theoretical instruction is standardized. The weekly theory sessions (2 academic hours) for all three classes are conducted simultaneously, with core knowledge points explained uniformly to ensure consistent and unbiased knowledge delivery.

Regarding differentiated practical training design, drawing from existing scholarly research and adapting to our specific context, three practical session models were developed: Class A students engage in “independent analyst”-style practice, completing one project every three weeks with one-on-one instructor feedback on individual analysis outcomes; Class B students simulate corporate data analysis teams, requiring group planning, collaboration, mid-term proposal presentations, and final integrated report submissions; Class C adopts a conventional lab format where students progressively replicate instructor demonstrations, sequentially completing skill training scattered across textbook chapters.

To ensure fairness, instructors, program directors, and external teaching consultants evaluated project difficulty. Class B’s integrated project was confirmed to match the combined complexity of Class A’s three individual projects, establishing this experimental design as equitable.

2.3 Effectiveness Evaluation System

The teaching effectiveness will be assessed across the following three dimensions:

Table 2.1 Teaching Effectiveness Evaluation Form

Evaluation Dimension	Evaluation Method	Evaluation Timing
Project Practical Skills	Score outcomes using the Project Scoring Sheet (Maximum 100 points)	Week 15
Core Operational Skills	Independent analysis of real data within a 2-hour time limit (on-site scoring)	Week 16
Theoretical Knowledge Mastery	Final closed-book examination (covering over 90% of knowledge points)	Final Unified Examination

The design of the project grading rubric is comprehensively structured based on the competency objectives outlined in the course standards. It assesses mastery of various skills, including whether data cleaning procedures are standardized, whether analytical methods are properly applied, and whether report logic is clear and reasonable. Additionally, since Class B’s practical component is designed as teamwork, the final grade consists of a group total score and an individual contribution score. The individual contribution score is determined through peer evaluation within the group, with the two components weighted at the 7:3 ratio.

2.4 Data Analysis Methods

To validate differences in practical teaching effectiveness, this study adopted a quantitative comparative paradigm with the following procedures. First, preliminary observations were conducted, descriptive statistics were applied to the average scores of the three student groups. Second, Levene’s test was used to verify homogeneity of variance during the prerequisite analysis phase. In the critical testing phase, one-way ANOVA was applied to examine mean differences across the three groups for each of the three indicators, determining whether significant overall differences existed among the groups. If significant results were found, post-hoc testing proceeded; the Tukey HSD test was employed for pairwise comparisons among the three groups. Finally, conclusions were drawn and relevant recommendations provided.

3.Data Collection and Organization

To ensure the authenticity and reliability of research data, this study systematically collected and processed teaching data from three classes of the “Fundamentals of Data Analysis” course between March and July. The entire process was implemented in accordance with enterprise data analysis procedures, following these specific steps:

3.1 Data Sources

Data sources comprise comprehensive records of the teaching process. Regarding project outcome archives:

- (1) Class A (individual project-based learning) collected 45 valid reports—three independently completed project reports per student.
- (2) Class B (team project-based learning) gathered comprehensive project documentation from five groups and 15 peer contribution evaluation forms within each group.
- (3) Class C (traditional teaching) did not involve project grading; chapter-based practical assignments were retained as

process records.

For competency assessment data, practical evaluations comprised timed skill tests administered uniformly to all three classes during Week 16. Theoretical assessments utilized the Academic Affairs Office's standardized final examination papers.

Regarding quality control measures: Project grading implemented double-blind, back-to-back evaluations, with program directors and instructors scoring independently. A three-party review was initiated if score discrepancies exceeded 5 points. Practical assessments featured proctored environments, with exam computer labs blocking external networks and recording screens throughout for evidence preservation.

3.2 Data Cleaning

To address common issues in the raw data, this study implemented a three-step cleaning process according to statistical protocols. Seven project reports were revised to resolve scoring discrepancies. The final valid sample characteristics are summarized as follows:

Table 3.1 Valid Sample Characteristics

Class	Project Score Sample	Practical Score Sample	Theory Score Sample
Class A	15students	15students	15students
Class B	15students	15students	15students
Class C	15students	15students	15students

3.3 Data Conversion: Standardized Evaluation Scale

Due to variations in the weighting of scores across different classes' practical projects, a standardized evaluation scale must be established prior to data analysis. This primarily involves converting individual contributions within Class B's team project scores. It was predetermined that team project scores comprise 70% group base points and 30% individual contribution coefficients. Thus, Class B's scoring formula is: Final Individual Score=(Group Score*0.7)+(Group Score*0.3)* Contribution Coefficient.

Following the data collection and organization phase, this study yielded three sets of analyzable data, which can be used to address the core question of how different practical teaching models impact student competencies.

4.Data Analysis

4.1 Descriptive Statistics

The study primarily employed a group comparison approach to examine whether students' performance across various metrics improved after adopting the project-based teaching model. To preliminarily assess the impact of different teaching models on student competencies, descriptive statistics were first applied to the three classes' performance across three dimensions: project implementation ability, core operational skills, and theoretical knowledge mastery. The analysis focused on examining the mean levels of each group's scores, providing an intuitive display and comparison of the differences in mean values among the three groups. Statistical indicators included the mean, standard deviation, and score range, with results presented in Table 4.1.

Table 4.1 Descriptive Statistics for Students' Three Performance Measures

Class	Measure	Mean	Standard Deviation	Range
Class A	Project Score	84.95	4.35	78.4-94
Class A	Practical Score	82.76	5.54	73.1-91.6
Class A	Theory Score	78.45	7.47	65.0-89.9
Class B	Project Score	90.01	4.17	82.9-96.7
Class B	Practical Score	80.54	6.35	68.7-90.9
Class B	Theory Score	77.09	6.92	65.9-88.7

Class	Measure	Mean	Standard Deviation	Range
Class C	Project Score	74.42	6.10	64.2-84.6
Class C	Practical Score	70.32	6.78	58.0-82.5
Class C	Theory Score	76.36	5.78	66.9-85.2

As shown in Table 4.1, in terms of project implementation skills, both Class A (individual projects) and Class B (team projects) achieved higher average scores than Class C (traditional teaching), with Class B recording the highest average score. Regarding core operational skills, Class A scored slightly higher than Class B, and both significantly outperformed Class C. However, in theoretical knowledge mastery, the average scores across the three classes showed minimal variation.

4.2 Prerequisite Tests

Descriptive statistics can only illustrate the magnitude relationships within a dataset and cannot conclusively demonstrate that differences in the means of different groups are statistically significant. To assess whether the differences in the means of the three groups are statistically significant, we will proceed to conduct a more detailed comparative analysis and investigation of the group means using the ANOVA method and Tukey HSD test. First, ANOVA will be employed to analyze mean differences. However, prior to analysis, we must verify whether the collected data satisfy the fundamental assumptions of normality and homogeneity of variance. After conducting Shapiro–Wilk tests on the residuals of each data group, the results show P-values greater than 0.05. This indicates that all three data groups substantially conform to the assumption of normal distribution, passing the normality test. Following Levene’s test for homogeneity of variances, the P-values for both project scores and practical scores exceeded 0.05, confirming that variance homogeneity was satisfied. Theoretical scores also met the variance homogeneity requirement. Consequently, all three indicator datasets in this study are suitable for mean difference testing using one-way ANOVA.

4.3 One-Way Analysis of Variance

To determine whether statistically significant differences exist among the mean values of the three data sets, the study employed the commonly used statistical comparison method ANOVA to conduct a one-way analysis of variance. After performing the ANOVA analysis on the three data sets using the AOV function in R software, the results are presented in Table 4.2.

Table 4.2 ANOVA Analysis Results

Indicator	F-value	Degrees of Freedom	P-value	Conclusion
Project Score	67.74	(2,42)	<0.001	Significant differences exist among the three groups
Practical Score	8.84	(2,42)	<0.001	Significant differences exist among the three groups
Theoretical Score	0.42	(2,42)	0.75	No significant differences exist among the three groups

The analysis results from the ANOVA method indicate that in project practical ability (project score), the analysis shows F-value=67.74 and P-value<0.001, thus demonstrating extremely significant differences between teaching models. For core operational skills (practical skills score), the analysis yielded an F-value of 8.84 and a P-value<0.001, indicating significant differences. However, for theoretical knowledge mastery (theory score), the analysis showed an F-value of 0.42 and a P-value of 0.75, indicating no significant differences. Based on the comprehensive ANOVA analysis results, the project-based teaching model significantly impacts students’ project practice abilities and core operational skills, but has no discernible effect on theoretical performance.

4.4 Post-hoc Comparisons

To further determine whether significant differences exist between the average scores of the experimental group classes using the project-based teaching model and those of the control group classes, pairwise comparisons among the three classes will be conducted. For this purpose, the Tukey HSD test from statistical methods was selected to perform pairwise comparisons

between the experimental group data and the control group. This study employed the TukeyHSD function in R software to perform TukeyHSD tests on the three sets of data, enabling pairwise comparisons. The results are presented in Table 4.3.

Table 4.3 Tukey HSD Test Results

Indicator	Group Comparison	Mean Difference	95%CI	P-value	Conclusion
Project Score	A-B	-5.07	[-8.71,-1.43]	0.004	B is significantly higher than A
Project Score	A-C	11.91	[8.27,15.54]	<0.001	A is significantly higher than C
Project Score	B-C	16.97	[13.34,20.61]	<0.001	B is significantly higher than C
Practical Score	A-B	-0.42	[-6.16,5.32]	0.983	No significant difference
Practical Score	A-C	8.80	[3.06,14.54]	0.002	A is significantly higher than C
Practical Score	B-C	8.38	[2.65,14.12]	0.003	B is significantly higher than C
Theoretical Score	A-B	0.78	[-4.99,6.55]	0.94	No significant difference
Theoretical Score	A-C	-1.01	[-6.78,4.76]	0.91	No significant difference
Theoretical Score	B-C	-1.79	[-7.56,3.98]	0.73	No significant difference

By examining the results of the Tukey HSD test, it is evident that the confidence intervals for the differences in average scores across different teaching models do not include the value 0. Based on the p-values: - For the project component, Class B (team project) achieved the highest score and significantly outperformed Class A (individual project) and Class C (traditional teaching). Class A also significantly outperformed Class C. - For the practical skills component, both Class A and Class B significantly outperformed Class C, but the difference between Class A and Class B was not significant. - For the theoretical knowledge component, no significant differences were found among the three groups.

5. Analysis Results

5.1 Project Practical Ability

According to the results of single-factor analysis of variance, significant differences were found in project-based practical skills among the three student groups. Further Tukey HSD post-hoc comparisons revealed that Class B (team project-based) achieved the highest scores, significantly outperforming Class A (individual project-based) and Class C (traditional instruction). Class A also significantly outperformed Class C.

These findings indicate that the project-based teaching model significantly enhances students' project-based practical skills, with team projects demonstrating optimal performance in comprehensive and complex tasks.

5.2 Core Operational Skills

Regarding core operational skills, significant differences were also observed across the three groups. Tukey's HSD post-hoc test revealed that both Class A (individual project-based) and Class B (team project-based) achieved significantly higher scores than Class C (traditional teaching), while no significant difference existed between Class A and Class B.

This indicates that both individual and team project-based approaches significantly enhance students' practical skills, while traditional teaching demonstrates clear shortcomings in cultivating operational competencies.

5.3 Mastery of Theoretical Knowledge

Regarding theoretical performance, no significant differences were observed among the three groups of students. Post-hoc Tukey HSD tests also failed to reveal any significant differences between groups.

This result indicates that students' mastery of theoretical knowledge primarily relies on standardized classroom instruction and textbooks. Differences in teaching models do not significantly impact students' theoretical performance.

5.4 Summary of Findings

In summary, this study yielded the following key results:

1. project-based teaching significantly outperformed traditional teaching methods, effectively enhancing students' practical

skills regardless of whether individual or team-based approaches were employed.

2.The team-based approach demonstrated clear advantages in comprehensive projects, with the team collaboration practice class achieving the highest practical scores. This indicates that teamwork is more conducive to solving complex problems and fostering the development of students' comprehensive abilities.

3.The individual model aids in foundational skill training, with independent operation classes achieving comparable practical scores to teamwork classes. This demonstrates that completing projects independently better hones students' mastery of basic skills.

4.Theoretical performance remains unaffected by teaching models, as no significant differences exist among the three groups' theoretical scores. This indicates that standardized theoretical courses are the primary determinant of theoretical knowledge acquisition.

6.Related Discussions

6.1 The Significant Enhancement of Practical Skills Through Project-based Instruction

The findings of this study indicate that project-based instruction significantly outperforms the traditional “chapter-by-chapter lecture + practice” model, regardless of whether implemented individually or in teams. This conclusion aligns with most existing research, which demonstrates that learning driven by authentic tasks can markedly improve students' professional skills and overall competence. In this study, project-based learning not only guided students through the complete data analysis process (problem definition-data cleaning and processing-data analysis-result interpretation) but also enabled them to continuously practice within contextualized tasks. This approach cultivated their problem-oriented thinking and enhanced their ability to logically structure and analyze issues.

6.2 Differentiated Advantages of Individual and Team Modes

The findings reveal that team project classes significantly outperformed individual project classes in project scores, indicating that collaborative practice exercises are more conducive to solving complex problems. This aligns with the “collaborative learning theory” in management and education studies. Collaborative learning theory posits that through division of labor and cooperation, students can share cognitive resources within groups, compensate for individual shortcomings, and thereby achieve better overall performance.

Additionally, individual project classes demonstrated comparable practical skills to team project classes, indicating that the individual model is more suitable for foundational skill training and fundamental competency reinforcement. These findings suggest that the individual model excels in skill development, while the team model excels in integrating capabilities. This complementary dual-model approach offers valuable insights for related course design.

6.3 Stability of Theoretical Performance

Regarding theoretical performance, no significant differences were observed among the three groups, indicating that mastery of theoretical knowledge primarily relies on standardized classroom instruction and textbook content. This finding aligns with conclusions from comparative studies, suggesting that teaching organization methods have limited impact on theoretical learning, while students' theoretical performance is more dependent on the overall curriculum framework and unified assessment standards. This conclusion also prompts us to maintain consistency in theoretical instruction during the current curriculum reform process, while pursuing differentiated innovation through practical components.

6.4 Teaching Implications

The findings of this study offer the following insights for curriculum reform and instructional design:

(1)Project-based course implementation should become the core model for higher vocational data analysis courses. It significantly enhances students' practical and applied skills, addressing the shortcomings of traditional teaching in skill development.

(2)The dual-mode complementary approach of individual and team projects warrants promotion. The individual mode suits the introductory stage, helping students master fundamental operational skills, while the team mode is appropriate for the advanced stage, training students in solving complex problems and enhancing team collaboration abilities.

(3)A tiered course design aligns with students' cognitive progression. This curriculum reform may adopt a blended tiered

approach-such as “individual projects in the early phase, team projects in the later phase” or “foundational individual projects, advanced team projects”-to achieve a spiral advancement in students’ practical abilities.

(4) Theoretical instruction should maintain consistency. The current unified teaching approach-standardized textbooks, uniform lectures, and consistent assessments-should be sustained to ensure systematic mastery of theoretical knowledge. This should be complemented by innovations in practical components to foster students’ comprehensive skill development.

6.5 Comparison and Extension of Previous Research

Compared to the more frequently explored “multiple-teacher-per-course” model in recent years, this study, while focusing on a different teaching model, employs the same quantitative evaluation approach of “parallel-class comparison+ANOVA+Tukey HSD.” This demonstrates that both teacher-combination and project-based models can utilize identical statistical methods to assess teaching effectiveness and establish replicable research paradigms. The innovation of this study lies in its detailed comparison of individual versus team-based project-driven approaches, providing more granular empirical evidence for instructional design in such courses.

7. Conclusions and Recommendations

7.1 Research Findings

This study concludes that project-based teaching significantly outperforms traditional models in enhancing students’ practical skills. Both individual and team-based project approaches markedly improve students’ hands-on capabilities. Additionally, each mode exhibits distinct advantages: team-based learning excels in developing comprehensive competencies, while individual projects prove superior for mastering foundational skills. Furthermore, theoretical performance remains unaffected by teaching mode, as differences in theoretical scores are insignificant. This indicates that theoretical learning primarily relies on standardized instructional components.

7.2 Teaching Recommendations

Project-based teaching can be promoted as the core model for higher vocational data analysis courses. When implementing curriculum reform using this model, instructors may flexibly adopt either the individual project mode or team project mode based on corresponding talent development objectives, or employ a tiered combination approach. Additionally, consistency in theoretical instruction must be maintained to ensure the stability of students’ knowledge frameworks. A multidimensional evaluation system integrating theoretical performance, practical skills, and project outcomes should be established to comprehensively assess student learning.

7.3 Research Limitations and Future Directions

While this study demonstrated that project-based teaching significantly enhances students’ practical skills, certain limitations remain. These primarily include a restricted sample size and the need to broaden evaluation dimensions. Future research could expand the sample and incorporate psychological dimensions such as learning motivation and self-efficacy to conduct interdisciplinary and cross-major studies. Additionally, the long-term effectiveness of this model should be examined by integrating data from students’ graduation internships and workplace performance.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research on Modernising Innovation and Entrepreneurship Education in New Business Disciplines at Applied Universities through Artificial Intelligence Empowerment

Hana Wang*, Sicheng Peng

School of Business, Hunan Institute of Engineering, Xiangtan, 411104, China

**Corresponding author: Hana Wang, 274502561@qq.com*

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Abstract: This paper explores pathways and strategies for the AI-driven modernisation of innovation and entrepreneurship education within the new business disciplines of applied universities. It begins by analysing the urgent demand for interdisciplinary business talent in the digital economy, emphasising the outdated nature of traditional business education in terms of its content, methodology and assessment mechanisms. It then outlines the new requirements for AI-enhanced innovation and entrepreneurship education in terms of talent development, curriculum design, teaching models, faculty development, evaluation systems and practical platforms. Finally, the paper systematically presents AI-powered modernisation pathways for innovation and entrepreneurship education through seven dimensions: strategic planning, curriculum restructuring, pedagogical innovation, faculty optimisation, evaluation refinement, platform upgrades, and industry-university collaboration. These initiatives aim to drive profound educational transformation and cultivate applied professionals who possess business acumen, technical expertise and an innovative spirit.

Keywords: Artificial Intelligence(AI); Innovation and Entrepreneurship; Business; College Students

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1.Introduction

The rapid advancement of artificial intelligence technology is fundamentally reshaping business ecosystems and talent requirements, ushering in a new phase of high-quality business education centred on innovation and entrepreneurial capabilities. As key drivers of regional economic growth, applied universities must urgently address the demand for interdisciplinary and innovative talent in the digital era through their business education programmes. However, traditional business education still suffers from issues such as a lack of connection to practical applications and rigid pedagogical models. This means it fails to meet students' real-world needs for 'innovation and entrepreneurship' competencies in the new economy. Integrating AI into new business education not only meets the inevitable requirements of technological integration and model innovation, but also serves as a crucial pathway to modernising education and enhancing the quality of talent cultivation. This paper systematically explores how AI can empower new business education with 'innovation and entrepreneurship' capabilities in applied universities, examining three aspects: necessity, emerging demands and developmental pathways. The research aims to provide theoretical references and practical guidance for related educational practices.

2. The necessity of developing ‘double creation’ education in application-oriented business schools

2.1 Economic change and evolving requirements for business education

Industrial upgrading and evolving demands for business talent. The rapid development of the digital economy and profound industrial restructuring have led to the creation of numerous new business models and cross-disciplinary roles. These emerging roles require professionals to demonstrate not only solid expertise, but also interdisciplinary application skills, complex problem-solving capabilities and an ‘innovation-driven entrepreneurship’ mindset. The digital transformation of industries has created new requirements for the competency framework of business professionals. Modern commercial operations require professionals who are digitally savvy and can utilise AI tools for data analysis, market forecasting and business decision-making ^[1]. This industry-driven educational transformation means that new business education must prioritise cultivating innovation-driven entrepreneurial capabilities. Through interdisciplinary integration and practical training, the aim is to develop students’ core competencies that are essential for adapting to the needs of future business development.

Table 1: A comparison of traditional and new approaches to business education.

Comparative dimensions	Traditional business education	New Business Education
Course focus	Theoretical knowledge and single skill	Interdisciplinary integration and “double innovation” ability
Teaching method	Teacher-led, classroom teaching	Student center, project driven, practice oriented
Ability training	Knowledge memory and test-taking ability	Problem solving, innovative thinking, teamwork
Evaluation mechanisms	Examination results are the dominant factor	Multiple evaluation, emphasis on process and practical results
Industry linkages	Lagging behind industrial development	Develop in step with the industry and make forward-looking arrangements

The disconnect between traditional business education and the demands of the new economy. Traditional business education is faced with three critical challenges when it comes to meeting the needs of economic development in the new era: Firstly, outdated curricula fail to reflect the latest trends in the growth of the digital economy. Secondly, teaching methods are monotonous and rely too heavily on theoretical lectures, lacking practical scenarios and project-driven training. Thirdly, rigid evaluation mechanisms prioritise knowledge assessment over evaluating innovative capabilities and practical skills. Table 1 compares traditional and modern business education. This results in graduates struggling to meet corporate requirements, creating a structural contradiction where ‘employment difficulties’ coexist with ‘recruitment challenges’. Furthermore, it severely undermines the effectiveness of entrepreneurship education programmes, making it difficult to cultivate high-quality business professionals who can meet the demands of the new economy ^[2].

The connotation of new business education and its relationship with ‘mass entrepreneurship and innovation’ education. Building upon traditional business education, new business education directly addresses the new demands, changes, stages, characteristics and challenges of the economy and society. It incorporates new technologies, methods, concepts, models and systems into the traditional curriculum, reorganising and intersecting traditional business disciplines in order to respond to new situations, issues, competitions, requirements and goals brought about by technological, social, economic, environmental and climatic factors. This approach highlights the distinctive theories and methods of Chinese business studies ^[3]. New business education emphasises interdisciplinary integration with engineering, science, humanities, and social sciences, focusing on cultivating students’ innovative thinking and entrepreneurial capabilities to help them navigate uncertain business environments. ‘Mass Entrepreneurship and Innovation’ education and the development of new business education share intrinsic consistency and mutual reinforcement. On the one hand, ‘Mass Entrepreneurship and Innovation’ education serves as a crucial component and methodological pathway for the development of new business education. Conversely, new

business education provides the knowledge foundation and capability framework for ‘Mass Entrepreneurship and Innovation’ education. Through cultivating “business-driven innovation, business-assisted innovation, business-activated innovation, and business-powered innovation”, a chain-integrated “Business Education +” and “Mass Entrepreneurship and Innovation” collaborative education system is formed. This transforms “Mass Entrepreneurship and Innovation” education from a universal approach to one that is quality-oriented.

2.2 The development orientation of application-oriented universities and the inherent requirements of talent training

The core mission and positioning of applied universities. As distinct higher education institutions, they are dedicated to serving regional socioeconomic development by cultivating high-calibre professionals for the production, management and service sectors. Unlike research-oriented universities, they emphasise practical education with a strong vocational focus ^[4]. Their business education must closely align with regional economic needs in order to produce management talent that can drive industrial transformation and corporate innovation. This requires breaking traditional disciplinary boundaries to establish industry-education integration and school-enterprise collaboration mechanisms. Incorporating real-world business projects and industry challenges into the curriculum enables students to gain hands-on experience in acquiring knowledge and developing practical skills through real-world applications.

The strategic value of ‘mass entrepreneurship and innovation’ for applied universities. “Mass Entrepreneurship and Innovation” education holds significant strategic value for applied universities, serving as a crucial pathway to connotative development, distinctive growth and quality enhancement. Firstly, this educational model drives reforms in applied university education by breaking away from traditional pedagogical constraints. This establishes teaching approaches that align with the characteristics of cultivating applied talent. Secondly, it promotes the integration of industry and education and collaboration between schools and enterprises, strengthening the connection between academic institutions and socio-economic development and enhancing their capacity to serve local communities. Finally, this type of education helps to shape institutional identity and boost the competitiveness of universities by offering distinctive educational features.

Table 2: The role of new business disciplines in improving the quality and efficiency of innovation and entrepreneurship education at applied universities.

Dimension of action	Embody	Case examples
Optimization of talent training process	Project-driven, increased student Engagement	Jiangsu Institute of Technology “Business to Innovation” curriculum system
Improving teaching quality	Cultivation of practical ability and innovative spirit	Fourth stage practical teaching mode of Geely College
Improvement in subject competitions	The number and level of awards have increased	The number of competition awards at Zhanjiang Institute of Technology increased by 13 times
Improvement in the quality of employment	Employment competitiveness and success rate of entrepreneurship increased	Jiangsu Institute of Technology has many successful cases of entrepreneurship
The capacity of social services has been enhanced	Integration of production and education and deepening cooperation between schools and enterprises	Nearly 1,000 graduates of Zhanjiang Institute of Technology have joined top companies in the Greater Bay Area

The importance of quality improvement and efficiency enhancement in “mass entrepreneurship and innovation” education within the new business discipline framework. Within this framework, “mass entrepreneurship and innovation” education plays a significant role in enhancing the quality and efficiency of talent development at applied universities. On the one hand, it can optimise the talent cultivation process by adopting project-driven approaches, competition-led initiatives and practical training methods, thereby enhancing students’ learning interest and participation while cultivating their practical skills and innovative spirit. On the other hand, it improves the quality of talent development, ensuring that graduates are better aligned with industry demands, enhancing their employability and entrepreneurial capabilities. Many applied universities in China

have significantly improved their students' 'mass entrepreneurship and innovation' outcomes by establishing a curriculum system, training framework, competition mechanism and support system empowered by business disciplines. Specific cases are illustrated in Table 2.

2.3 The realistic demand for the comprehensive development, employment and entrepreneurship of college students

The need to enhance college students' 'mass entrepreneurship and innovation' competencies. Currently, college students generally lack the necessary "mass entrepreneurship and innovation" competencies, falling significantly short of societal demands. Many applied university students demonstrate a lack of awareness, dedication and capability in this area. While many students express a strong interest in 'mass entrepreneurship and innovation', surveys indicate that they often lack the necessary knowledge, skills and practical experience to transform ideas into tangible projects or establish businesses. Meanwhile, the challenging employment landscape urgently requires comprehensive 'mass entrepreneurship and innovation' education to boost employability and entrepreneurial readiness. This type of education can substantially improve students' professional application skills, interdisciplinary integration abilities, teamwork capabilities and market insight. By participating in 'Mass Entrepreneurship and Innovation' projects and gaining practical experience, students can apply their expertise to solve real-world problems, thereby cultivating critical thinking and creative problem-solving skills, as well as the ability to tackle complex challenges.

The impact of 'mass entrepreneurship and innovation' education on new business education and employment quality. Under the new business education framework, the 'Mass Entrepreneurship and Innovation' education significantly improves employment quality for college students. It helps students adapt more easily to the demands of an evolving job market, boosting their competitiveness and career development capabilities. Practical evidence shows that, through systematic planning of clusters of new engineering, business, medical and humanities disciplines, universities can substantially strengthen their capacity to serve local development by dynamically optimising disciplinary structures and aligning closely with national strategies and regional industrial needs. Furthermore, this educational model fosters an entrepreneurial spirit and capabilities, inspiring students to establish their own enterprises and generate new job prospects. Business education empowers students to participate in the 'Mass Entrepreneurship and Innovation' initiative, which facilitates multi-path growth, including independent entrepreneurship, position-based entrepreneurship, and high-quality employment.

3. New requirements for 'double innovation' education in new business schools against the backdrop of artificial intelligence

3.1 Upgrading talent training requirements

The rapid advancement of artificial intelligence has driven profound transformations in business models, while simultaneously creating new demands for the cultivation of 'innovation and entrepreneurship' talent in the emerging business disciplines of applied universities. Traditional 'innovation and entrepreneurship' education, which focused on developing professionals with foundational business knowledge and entrepreneurial skills, has evolved in the context of AI. The current educational objective is to cultivate interdisciplinary innovators who can integrate 'AI + business + innovation and entrepreneurship'. These individuals must not only grasp solid business theories and innovation methodologies, but also demonstrate practical problem-solving abilities using AI technologies. They must also exhibit ethical awareness in AI applications and possess cross-disciplinary collaboration skills.

From an industrial perspective, the widespread application of AI in commercial sectors has given rise to new roles such as intelligent marketing, smart finance and intelligent supply chain management. These roles require professionals to utilise AI technologies such as machine learning and big data analytics for tasks such as market forecasting, customer profiling and optimising business decisions. New business education programmes at applied universities under the 'Mass Entrepreneurship and Innovation' initiative should therefore align with these emerging job requirements by integrating AI application capabilities as a core component of talent development objectives.

3.2 Requirements for innovation in teaching methods

Advances in artificial intelligence technology have provided technical support for an innovative 'mass entrepreneurship and

innovation' education model in the new business disciplines of applied universities, while simultaneously demanding reforms to traditional teaching approaches. The traditional "teacher-centred, lecture-based" pedagogical model urgently needs to be transformed into a new paradigm characterised by "student-centred learning, technological empowerment and a practical approach".

Firstly, AI technology enables the implementation of personalised teaching models. Intelligent learning analytics systems enable teachers to develop personalised learning plans by analysing students' behavioural data, thereby enhancing learning initiative and efficiency. Secondly, virtual simulation education is a vital supplement to practical training. The integration of AI and virtual simulations enables highly realistic business scenarios and innovation ecosystems to be created. This virtual environment effectively addresses limitations in traditional practical teaching, such as restricted facilities and high costs^[5], while providing students with opportunities to conduct market research, develop products, devise marketing strategies and manage enterprises. Thirdly, project-based learning and collaborative teaching models have gained widespread adoption. Given the complexity and interdisciplinary nature of AI-driven business innovation, project-based learning engages student teams in solving real-world problems using business knowledge and AI technologies. Meanwhile, collaborative teaching teams comprising business instructors, AI specialists and corporate mentors facilitate the integration of interdisciplinary knowledge and the coordinated development of practical skills.

3.3 Requirements for curriculum system reconstruction

In the context of artificial intelligence, the 'mass entrepreneurship and innovation' education curriculum in the new business disciplines of applied universities must break through traditional disciplinary barriers and be systematically restructured to achieve the deep integration of business knowledge, AI technology and innovation capabilities. Conventional curricula often comprise business courses, AI courses, and innovation programmes that operate in isolation from one another, resulting in a fragmented approach that fails to meet the demand for interdisciplinary talent. Therefore, curriculum restructuring should adhere to the principles of 'integration, practicality, and foresight'.

The curriculum should be designed as a multi-tiered system comprising "core foundation courses + modular electives + practical projects". The core foundation courses should cover business fundamentals, AI theories and the basics of innovation-driven entrepreneurship to develop students' interdisciplinary expertise. Modular electives should integrate regional industrial features and student development needs through specialised modules such as intelligent marketing, smart finance and cross-border e-commerce operations to cater for diverse learning objectives. Practical project courses should be integrated throughout the talent development process to transform theoretical knowledge into practical skills by engaging students in real-world, AI-driven innovation projects within authentic business scenarios.

3.4 Requirements for teacher training

The faculty team is essential for ensuring the quality of entrepreneurship and innovation education within the new business disciplines of applied universities. In the AI era, higher demands are placed on the competency structure and development models of teaching staff. Traditional faculty members often lack AI application skills, while AI specialists frequently lack business knowledge and an understanding of innovation practices. These gaps hinder the integration of 'AI + Business + Innovation' into teaching. Therefore, faculty development should focus on three key aspects: enhancing competency, optimising structure, and diversifying recruitment channels.

In order to enhance teaching capabilities, we must strengthen cross-disciplinary training for faculty members. This involves organising AI technology workshops and executive training programmes, as well as arranging internships at AI enterprises for business education instructors to gain hands-on experience, thereby improving their technical proficiency and interdisciplinary teaching skills. Secondly, we should encourage AI instructors to study business knowledge and innovation-driven entrepreneurship theories to enhance their commercial literacy and practical teaching abilities. In terms of structural optimisation, we need to establish a multidisciplinary faculty team that integrates business studies, AI and innovation-driven entrepreneurship. This requires recruitment and development efforts to attract professionals who are proficient in both business disciplines and AI technologies. At the same time, we should consolidate campus resources to form interdisciplinary teaching teams and optimise faculty allocation. To source diverse talent, we should strengthen industry-academia

collaboration by involving frontline corporate experts in instruction. Inviting AI specialists and business innovation mentors to join us as adjunct faculty or practical instructors would enable us to share the latest industry trends, technical applications and innovation-driven entrepreneurship case studies, effectively addressing the shortage of practical experience among our existing faculty.

3.5 Requirements for improvement of the evaluation mechanism

In the context of artificial intelligence, the evaluation mechanism for ‘mass entrepreneurship and innovation’ education in applied universities’ new business disciplines must transcend the traditional limitations of ‘knowledge assessment dominance and result-oriented evaluation’. This requires the establishment of a comprehensive evaluation system featuring multi-stakeholder participation, multidimensional indicators and balanced consideration of processes and outcomes. This will enable a more holistic and objective assessment of students’ overall qualities and capabilities ^[6].

In terms of evaluators, there should be greater diversity. The new evaluation mechanism should incorporate multiple stakeholders, such as student self-assessment, peer review, corporate evaluation and social assessment. Student self-assessment and peer review encourage self-reflection and awareness of teamwork. Corporate evaluation assesses students’ practical application abilities by providing feedback on internship performance and project outcomes. Social assessment evaluates students’ innovation capabilities and social contributions through the social impact and award-winning status of ‘mass entrepreneurship and innovation’ projects. Regarding evaluation criteria, a multidimensional system should be established. Indicators should cover knowledge mastery, skill development, and quality enhancement across multiple dimensions. The knowledge dimension should include core business knowledge, artificial intelligence fundamentals and ‘mass entrepreneurship and innovation’ knowledge. The skill dimension encompasses AI technology application, innovative thinking, practical operation, teamwork and communication skills. The quality dimension covers professional ethics, AI ethical literacy, and the ‘mass entrepreneurship and innovation’ spirit. In terms of evaluation methods, there should be an emphasis on combining process-oriented and outcome-oriented assessments. Process evaluation can utilise intelligent learning analytics systems to track and document students’ learning behaviours, classroom performance and project participation in real time, providing a comprehensive reflection of the learning process. Outcome evaluation can be conducted through final exams, project presentations and ‘mass entrepreneurship and innovation’ competition results.

3.6 Requirements for upgrading the practice platform

Practice platforms are vital for applied universities to implement practical education and innovation-driven initiatives within the “Mass Entrepreneurship and Innovation” framework. In the AI era, these platforms require comprehensive upgrades to integrate “AI + Business Studies + Innovation-Driven Development”. The upgrade strategy should prioritise three key areas: intelligent transformation, integrated systems and open ecosystems.

In terms of platform intelligence, integrating advanced AI technologies and equipment is essential for establishing intelligent practice environments. For example, an intelligent business data analysis lab could be built to support practical student activities such as market data analysis and customer profiling. Similarly, establishing a smart supply chain simulation lab would allow students to experience intelligent scheduling and risk warning systems in supply chain management. Regarding platform integration, we need to consolidate on-campus practice resources to achieve seamless connectivity between different laboratories and functional platforms. One example of this would be to integrate the Intelligent Marketing Lab, the Intelligent Finance Lab and the “Mass Entrepreneurship and Innovation” incubation platform into a unified “Smart Innovation Practice Centre for New Business Studies”. Strengthening collaboration between on-campus practice platforms and off-campus enterprise bases will also create an integrated ‘on-campus + off-campus’ practice ecosystem. To increase platform openness, we must break down campus boundaries to share resources with students, enterprises and society. Encourage students to independently apply for practice platforms for innovation-driven initiatives and to form teams to join incubation programmes. Secondly, we should provide technical R&D support and talent training services to attract real business projects from enterprises to the practice platforms, thereby fostering collaborative innovation between universities and companies.

4. Empowering the “double innovation” education development path of modernisation in applied universities with artificial intelligence.

4.1 Strengthen top-level design and clarify the development direction of AI-enabled ‘double innovation’ education.

A strong top-level design is essential for modernising AI-powered ‘mass entrepreneurship and innovation’ education in applied universities. These institutions should establish a systematic framework for top-level design by defining overarching objectives, core missions and implementation pathways for AI-enhanced business education. This should be developed through strategic planning that is aligned with institutional development goals.

Firstly, a specialised development plan should be developed. Universities should bring together experts and industry representatives from fields such as business education, artificial intelligence and innovation-driven entrepreneurship, in order to conduct in-depth research into regional industrial demands and AI technology trends. Aligning with the institution’s positioning and distinctive features, schools should then formulate actionable strategies outlining phased objectives, breaking down key tasks and clarifying departmental responsibilities, to ensure effective implementation. Secondly, a collaborative management framework should be established. Create dedicated administrative bodies to coordinate curriculum development, faculty training and the construction of practical platforms. Regular meetings should be held to address implementation challenges. Simultaneously, create cross-departmental collaboration mechanisms to break down the barriers between business schools and AI colleges and promote the integration of interdisciplinary resources and collaborative talent cultivation. Finally, enhance policy support systems. Develop policy documents that empower AI-enhanced business education and innovation-driven entrepreneurship programmes. These policies should specify funding, incentives and evaluation criteria for faculty development, platform construction and project incubation. Faculty members participating in interdisciplinary teaching teams and corporate internships should receive workload recognition and performance-based rewards. Outstanding student AI innovation projects should be awarded financial grants and incubation space.

4.2 Restructuring the curriculum system to achieve deep integration between artificial intelligence, business, and ‘double innovation’ education.

The core of modernising ‘mass entrepreneurship and innovation’ education in AI-powered applied universities is reconstructing the curriculum system. Guided by the principles of integration, practicality and foresight, we must break through traditional disciplinary boundaries to create a curriculum system that integrates AI, business studies and innovation-driven entrepreneurship.

Firstly, we will develop a multi-tiered curriculum framework. Focusing on talent development objectives, three tiers are established: Foundation, Core, and Extension. Foundation Level courses provide students with the fundamental theoretical knowledge of business, artificial intelligence and innovation-driven entrepreneurship. The Core Level focuses on integrating AI with business applications. Elective Extension Level courses cater for individual learning needs. Secondly, innovate course content and textbook development. We collaborate with university faculty and industry experts to incorporate real-world AI commercial cases into the classroom. We also create specialised textbooks that blend AI, business and innovation education, balancing theoretical depth with practical application. A dynamic content update mechanism ensures that the content is always aligned with the latest technological advancements in the AI and business sectors. Thirdly, we advance interdisciplinary curriculum clusters. Based on core courses, we establish cross-disciplinary clusters led by faculty members from the fields of business, AI and innovation. These clusters coordinate the integration of courses and design interdisciplinary practical projects.

4.3 Innovate teaching methods and utilise the potential of artificial intelligence in ‘double innovation’ education.

Innovating teaching models is crucial for modernising “mass entrepreneurship and innovation” education at applied universities powered by artificial intelligence. This requires the full utilisation of AI’s advantages to establish a new teaching model characterised by ‘personalisation, immersion, and collaboration’^[7].

Firstly, we promote personalised, intelligent teaching. Leveraging smart learning platforms achieves intelligent upgrades in the teaching process. Intelligent diagnostic systems assess students’ foundational knowledge upon enrolment and recommend personalised learning models and course resources based on the evaluation results. During instruction, the real-time collection

of student learning data through intelligent analytics enables teachers to accurately monitor progress and adjust their teaching strategies accordingly. Secondly, develop virtual simulation-based practical education. Create an intelligent ‘innovation and entrepreneurship’ virtual simulation centre for a new business discipline, developing experimental projects that cover areas such as smart marketing, intelligent finance and startup incubation. These simulations will be integrated into course curricula and will require students to complete designated virtual practice tasks that will contribute to their final evaluations. Thirdly, project-based collaborative learning should be implemented. Guided by authentic business projects, students will engage in team-driven learning. During implementation, collaborative teaching teams comprising business faculty, AI specialists and industry mentors will jointly mentor students. Working in groups, students will complete research projects, submit reports and present their findings, thus cultivating their teamwork skills and practical problem-solving abilities.

4.4 Strengthen teacher training and develop a multi-skilled ‘double innovation’ education team.

Faculty development is the cornerstone of modernising innovation and entrepreneurship education in AI-powered applied universities. We must integrate talent cultivation, recruitment and employment strategies to build a multidisciplinary teaching force combining business expertise, AI technical capabilities and hands-on experience in innovation-driven practices.

Firstly, improve the development of existing faculty members. Organise regular training sessions for business education instructors to participate in AI technology training. Create practical training bases where teachers can undertake internships at relevant enterprises and engage in the R&D of AI commercial application projects to accumulate hands-on experience. Host integrated teaching seminars, such as ‘AI + Business + Innovation-Entrepreneurship’ workshops, and teaching skills competitions, to encourage knowledge exchange among educators and enhance interdisciplinary teaching capabilities. Secondly, recruit high-calibre interdisciplinary talent. Implement preferential recruitment policies to attract professionals with cross-disciplinary backgrounds in AI and business studies who have real-world industry experience. These experts can teach integrated courses and lead teams in academic research and scientific projects, thereby driving overall faculty development. Finally, diversify part-time faculty recruitment. Collaborate with enterprises, industry associations and innovation-entrepreneurship incubators to hire AI specialists, business executives and successful entrepreneurs as adjunct or practice instructors. These part-time teachers will primarily deliver practical courses, provide project guidance and share case studies. They will also integrate the latest industry trends, technical applications and innovation-entrepreneurship cases into classroom instruction.

4.5 Improve the evaluation mechanism and establish a comprehensive, artificial intelligence-enabled evaluation system.

Improving the evaluation mechanism is crucial for modernising “mass entrepreneurship and innovation” education at applied universities powered by artificial intelligence. It is necessary to overcome the limitations of traditional evaluation and develop a system that is comprehensive, diverse, multidimensional and process-oriented, using artificial intelligence technology.

Firstly, establish a diverse evaluation framework. Then, develop an assessment system involving teachers, students, enterprises and social institutions. Teachers will evaluate students’ knowledge mastery, classroom performance and project guidance. Students will conduct self-assessments and peer reviews to reflect on their learning progress and evaluate their contributions to the team. Enterprises will evaluate practical application skills and professional ethics, and social institutions will assess innovation capabilities and social value. This multi-stakeholder approach ensures evaluations are comprehensive and objective. Secondly, design multidimensional assessment indicators. Focusing on three core dimensions - ‘knowledge, competence, and quality’ - specific metrics should be established. The knowledge dimension includes mastery of business core concepts, an understanding of foundational AI theories and the application of ‘mass entrepreneurship and innovation’ knowledge. The competence dimension covers AI technology operation, business data analysis, innovative thinking, practical skills, teamwork and communication abilities. The quality dimension encompasses professional ethics, ethical awareness, the ‘mass entrepreneurship and innovation’ spirit, and a sense of responsibility. Thirdly, implement a process-oriented intelligent evaluation system. Use AI technology to automate and optimise the assessment process. Smart learning platforms will track students’ learning progress data for quantitative evaluation, while intelligent assessment systems will provide real-time knowledge assessments to inform teaching decisions. Blockchain technology will be integrated into project evaluations to

verify students' participation and deliverables, ensuring authenticity and fairness.

4.6 Upgrade the practice platform to build an intelligent, integrated system for mass entrepreneurship and innovation.

The upgraded platform is a vital tool for modernising innovation and entrepreneurship education at applied universities through AI-powered initiatives. This involves integrating on-campus resources with external collaborations to create an intelligent, integrated system that combines 'on-campus smart practice platforms' and 'off-campus collaborative practice bases' [8].

Firstly, we will establish a cluster of intelligent practice platforms on campus. With a focus on the integration of "AI + Business + Innovation and Entrepreneurship", we will develop a series of specialised smart practice platforms. This will include the construction of a commercial big data analytics laboratory, equipped with the necessary tools to support students' practical activities, such as market data analysis and customer behaviour prediction. Additionally, an AI-powered business simulation lab will enable students to conduct marketing planning and financial service operations in virtual environments. An AI-driven innovation and entrepreneurship incubation centre will provide a range of services, including AI project diagnosis, intellectual property protection and investment financing connections for student projects. Secondly, we will establish off-campus collaborative practice bases. By strengthening our partnerships with AI companies, commercial enterprises and innovation incubators, we will establish external collaboration hubs together. In collaboration with major AI firms, we will establish AI commercial application practice bases, where students will undertake internships at enterprises and participate in the development of intelligent business projects. By partnering with local SMEs, we will establish innovation service bases where students will deliver technical services such as designing smart marketing solutions and analysing business data, thereby fostering collaborative innovation between schools and enterprises. Through our collaborations with innovation incubators, we will provide venue support, mentorship guidance and connections to market resources to facilitate project implementation and commercialisation.

4.7 Deepen school-enterprise cooperation and establish a collaborative education mechanism that enables 'double creation' education.

Strengthening university-industry collaboration is a vital way for AI-powered applied universities to modernise their business education and innovation and entrepreneurship initiatives. To overcome the limitations of traditional partnerships, which tend to be superficial and loosely structured, an in-depth cooperation mechanism must be established, featuring resource sharing, complementary strengths and collaborative talent development.

Firstly, they should work together to develop talent cultivation programmes. Under the New Business Education framework, both universities and enterprises collaborate in formulating talent development plans for the 'Mass Entrepreneurship and Innovation' initiative. Enterprises propose specific knowledge, skill and quality requirements based on their developmental needs and job roles. Universities then adjust their educational objectives, curriculum design and practical components to ensure precise alignment with these demands. Secondly, curricula and teaching materials should be co-created. Institutions and enterprises will work together to develop integrated courses and textbooks that combine 'AI + Business Studies + Mass Entrepreneurship and Innovation', with industry experts participating in the design of the content and compilation of the textbooks to incorporate real-world project cases and technical application experiences. Thirdly, faculty teams are built through a 'mutual recruitment' mechanism. Universities send faculty members to work as technical consultants or project leaders on corporate innovation initiatives, while enterprises send technical experts and managers to work as adjunct teachers, providing practical course instruction and project guidance. Finally, a collaborative ecosystem for mass entrepreneurship and innovation should be established. Create platforms such as AI innovation competitions and business innovation forums to engage students, corporate employees and social entrepreneurs, thereby fostering a vibrant atmosphere for mass entrepreneurship and innovation.

5. Conclusion

Artificial intelligence is not intended to replace traditional 'mass entrepreneurship and innovation' education, but rather to give it an unprecedented boost. For applied universities' new business disciplines, the modernisation of such education

through AI represents a profound paradigm shift. This requires institutions to adopt a strategic, top-level design approach and systematically reconstruct curricula, teaching methodologies and practical frameworks, while also promoting faculty transformation. The ultimate goal is to cultivate a new generation of business talent who understand commercial principles, can use AI tools effectively, and have an innovative spirit, entrepreneurial capabilities and a strong sense of social responsibility. Rather than being passive adapters, these individuals will become architects and pioneers, shaping future business ecosystems. While this transformation poses significant challenges, it also presents applied universities with a historic opportunity to achieve connotative development, distinctive growth and enhanced competitiveness.

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Conflict of Interests

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Teaching Model Exploration of Integrating Digital Literacy into Higher Vocational Mathematics Courses

Xinyi Hu*

Basic Science Department, Nanjing Polytechnic Institute, Nanjing 210048, Jiangsu, China

*Corresponding author: Xinyi Hu

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Abstract: Higher vocational mathematics education witnesses a historic transformation, driven by the development of information technology. Cultivating the digital literacy of vocational education normal students is a fundamental link in promoting the digital teaching reform of vocational education. This paper analyzes the necessity of integrating digital literacy into higher vocational mathematics courses under the current national strategies and employment market demands, and explores how digital literacy can facilitate students' learning. We primarily explores the teaching model of mathematics to enhance students' digital literacy, thereby generating a practical system. Through these changes, it will promote the cultivation of more high-quality technical and skilled talents in higher vocational colleges.

Keywords: Digital Literacy; Higher Vocational Education; Mathematics Education; Course Construction

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1.Introduction

The teaching reform of vocational colleges is the core thread of the development of vocational education in China, and its process deeply reflects the changes in the demand for technical and skilled talents in the economy and society^[1].

Nowadays, technologies such as artificial intelligence, big data, and virtual reality are deeply integrated into the entire process of professional construction, curriculum teaching, practical training and evaluation, achieving personalized learning, intelligent management, and cultivating students' digital literacy to adapt to future intelligent production.

The reform of mathematics teaching in vocational colleges is a concrete and crucial microcosm of its overall teaching reform, and its evolution clearly reflects the value shift of vocational education from emphasizing skill imparting to emphasizing comprehensive literacy and sustainable development capabilities^[2]. The core of the reform is the transformation of positioning: from an independent discipline to a tool based foundational course serving professional technical learning. Vocational colleges have begun to vigorously promote the reform of "modular teaching" and "application-oriented". The teaching content has been restructured into "basic modules" and "professional application modules". In terms of teaching methods, case-based teaching and project driven approaches have been introduced, attempting to help students appreciate the value of mathematics in solving practical problems. It fully demonstrates the current situation of deepening the integration of industry and education and embracing digital intelligence.

With the digitalization of industries, the teaching content of vocational mathematics will inevitably integrate more modern mathematical knowledge such as data analysis, statistical prediction, and optimization algorithms, cultivate students' data

thinking and computational thinking, and lay a foundation for them to adapt to the smart industry. The ultimate goal of the reform will go beyond imparting specific knowledge and focus more on cultivating students' core competencies through mathematical training, including logical reasoning ability, quantitative analysis ability, critical thinking, and innovative ability to solve uncertain problems. These qualities are key for students to cope with future career changes and achieve sustainable development.

The cultivation of digital literacy in higher vocational education is upgrading from an auxiliary skill list to a fundamental empowerment that supports students' lifelong learning and career development. Its goal is to equip future craftsmen with core mental models and key abilities to cope with the digital world, making them not only users of technology, but also active participants and rational guides in digital transformation.

2. Preface

2.1 Political Motivation of Cultivating Digital Literacy

Driven by the new round of technological revolution, according to the "Digital China Development Report (2024)"^[3], the scale of core industries in the digital economy has steadily expanded, accounting for about 10% of GDP. High-end industries like Internet Plus, embodied intelligence and AIGC are progressively integrating into our daily work routines and entertainment, driving social and economic development and transformation through digital technology.

In response to this development reality, in 2025, Opinions of the State Council on Deepening the Implementation of the "Artificial Intelligence+" Action^[4] says that we shall promote the development of industrial all factor intelligence, intelligent linkage of all industrial factors and accelerate the application of artificial intelligence in the entire process of design, pilot testing, production, service, and operation. We shall focus on improving the artificial intelligence literacy and skills of all employees, and promote the formation of more reusable expert knowledge in various industries. Also the Ministry of Education, along with nine other departments, jointly issued the "Opinions on Accelerating the Digitalization of Education"^[5], urging educators to expedite the development of large artificial intelligence education models, explore innovative paradigms for "AI + education" application scenarios, and facilitate the deep integration of these models into educational teaching practices. Promote the intelligent upgrading of the curriculum system, textbook system, and teaching system, and integrate artificial intelligence technology into all facets and stages of education and teaching. It underscores the pressing need for teachers and students to acquire the skills of the digital age, as recognized by society.

2.2 Practical Necessity of Curriculum Reform

Digital literacy is the ability of individuals to effectively use digital technologies, tools, and platforms to acquire, analyze, evaluate and create information^[6]. It encompasses not only the operational proficiency in digital technology but also the comprehension of information processing and communication within the digital environment, serving as a crucial impetus for the advancement of digital technology^[7]. Therefore, digital literacy has gradually been incorporated into the basic qualities of citizen learning in the digital society, and is also an important guarantee for the development of new quality productivity. It is a fundamental quality that every learner ought to prioritize and a key skill that universities should emphasize in their training. It helps the future career prospects of vocational students, necessitating in-depth research in this domain.

Currently, researchers' studies on integrating digital literacy into teaching primarily focus on enhancing teachers' digital literacy^[8], with less exploration of specific courses and a lack of digital literacy practices centered around students. Also, as students newly enter university, their understanding of learning knowledge is mostly limited to paper-based and book-inherent knowledge. While, most knowledge can be acquired online nowadays. Therefore, it needs an effective method to lead them to practice digital literacy in the classroom.

Furthermore, higher vocational mathematics courses, particularly 'Advanced Mathematics', serve as a mandatory course for freshmen in polytechnic colleges, functioning as a gateway to university studies and future careers. Undoubtedly, they play a pivotal role in enhancing students' overall quality. These courses encompass rigorous mathematical thinking methodologies and pragmatic applications of mathematics, empowering students to enhance their computational thinking skills and actively assume digital social responsibilities.

3.Strategies for Enhancing Digital Literacy

3.1 Revising Teaching Objectives

After years of educational reform, evaluation system of students' overall qualities has been continuously improved. Building upon three-dimensional objectives, the inclusion of digital literacy considerations enriches the existing system, enabling lesson planners to align their efforts with specific goals.

At the level of knowledge and skills objectives, emphasis should be placed on mastering specific information skills. This involves learning to utilize digital tools for calculating results, verifying mathematical conjectures, or presenting outcomes. For instance, one can calculate characteristics like the average of a dataset using Excel and SPSS, illustrate the convergence rate of sequence limits and the significance of vector dot product calculations using geometric drawing tools and Geogebra, and perform numerical calculations and simulations such as fitting and iteration through MATLAB and Python programming.

At the level of process and steps objectives, students should pay attention to the occurrence and development process, understanding various approaches to solving problems. For example, when learning calculus, they should understand the significance and use of approximate calculation of calculus through definition, and learn to use the idea of approximation to simplify computation in financial or engineering calculations. When confronted with problems that are difficult for individuals to solve, they actively recognize and utilize trained database and various AI question-answering platforms.

At the level of emotional attitude and values objectives, while being stimulated by new technologies and gaining motivation, students should form appropriate opinions on new development, embody information ethics towards technology, use tools temperately and avoid mental illnesses such as AI psychosis. Students shall respect labor achievements of others, pay attention to citation norms and data privacy protection, and consciously maintain data security in case of potential leakage of personal or national information.

3.2 Refining Blended Teaching Strategy

Modern higher education has incorporated emerging information technology, new media technology, and Internet resources into various courses. The digital literacy embodied in these tools, such as digital awareness, digital innovation, and learning, subtly brings efficiency and scalability into limited classrooms.

For example, by utilizing the SPOC teaching method that combines online and offline approaches, we can achieve a flipped classroom. Before class, students can watch micro-lecture videos on online platforms such as MOOC, Rain Classroom, and Supernova to acquire basic knowledge. This allows classroom time to be devoted to higher-order tasks.

After class, AI-generated questions on the platform can help students independently test and consolidate their understanding. We can further integrate digital resources tailored for higher vocational mathematics, such as encompassing interactive exercise and case libraries (like dynamic simulations of infectious disease models), and open-source code libraries (like augmented reality displays showcasing the dynamic distributions of vector fields), and enhance the knowledge graph for review after class.

For another example, we employ task-driven approach and practice-oriented teaching, design interdisciplinary projects (like big data analysis in financial risk models), incorporate situational test questions into daily teaching, and require students to integrate mathematical knowledge with programming language such as Excel or R language to complete reports. Meanwhile, in their spare time, students can develop interest groups in mathematical modeling to consolidate their learning achievements in solving problems using mathematical thinking and technological means.

3.3 Project-Based Learning Process

Project-based learning (PBL) requires students to solve a complex, real-world problem through teamwork over a period of time. This mode introduces professional mathematical calculation software and tools into the classroom which is a direct means to enhance students' digital literacy. These tools not only visualize abstract mathematical concepts, but also enable students to tackle complex problems that are difficult to solve with traditional methods. Therefore, it provides a practical field for the cultivation of digital literacy. For example, a study developed a mathematical electronic module based on STEM collaborative project-based learning, aimed at enhancing the mathematical literacy of vocational students.

In mathematics PBL, students need to do at least following three things. First, it requires students to study their own way

of information retrieval and evaluation to utilize online resources to search for industry data, technical standards, and background information related to the project. Second, data processing and analysis urges students to use spreadsheets, statistical software, and even programming languages to process and analyze collected data, and build mathematical models. Third, digital content creation and communication is also gained by students naturally by use presentation software, visualization tools, and online collaboration platforms to present research processes, mathematical models, and project outcomes.

By completing a complete project, students not only deepen their understanding of mathematical knowledge, but also integrate various digital skills through the process of “learning by doing”.

3.4 Optimizing Evaluation Mechanisms

The mathematics curriculum standards released by the Chinese Ministry of Education emphasize the cultivation of “core competencies” in both basic education and high school, including mathematical abstraction, logical reasoning, mathematical modeling, intuitive imagination, mathematical operations, and data analysis. This transformation coincides with the goal of cultivating digital literacy. Vocational mathematics courses should be guided by this and deeply map the various dimensions of digital literacy with the cultivation of core mathematical literacy.

We should incorporate more evaluation indicators into the system that evaluates students based on traditional homework and exams, so as to enable students to develop in a balanced way to meet industrial and social demand.

For example, in process assessment, performance based assessment requires students to demonstrate their knowledge and skills by completing a specific task or project. This is an ideal way to evaluate comprehensive abilities such as digital literacy. At present, although there is a lack of specific assessment tools specifically validated for vocational mathematics courses, we can draw on common digital literacy assessment frameworks and tools for design.

Students can submit a project portfolio that includes a complete process record of their use of digital tools for mathematical modeling, data analysis, and visualization. The evaluation focuses on the rationality of students’ tool selection, the standardization of data processing, the creativity of model construction, and the clarity of conclusion presentation. We adopt real-life cases for modular teaching, record students’ contribution on the digital collaboration platform and reward those who post high-quality content in the discussion forum or make significant contributions to mathematical modeling interest groups. We can also organize performance simulation design tasks that simulate real occupational scenarios. For example, students are required to use mathematical parameters from software to design a part, or use spreadsheet software to develop the optimal cost budget plan for a small and micro enterprise.

Developing and using Rubrics is important too. Rubrics are a key tool for implementing performance evaluations, which clearly define standards for different levels of performance, making evaluations more objective and transparent. We can draw on existing digital information literacy metrics, such as Diginfo Rubric in America and combined with the characteristics of vocational mathematics, carry out localization transformation, evaluate from multiple dimensions such as “application of mathematical knowledge”, “selection and operation of digital tools”, “data processing and interpretation”, “collaboration and communication”.

In outcome assessments, besides exams, diversified forms are adopted. Quantitative methods such as questionnaires can also be used to measure students’ computer self-efficacy, Internet attitude, digital learning ability and other potential characteristics, so as to more comprehensively understand the factors affecting their digital literacy development. Completing specific outcomes can also be counted as part of the grade, such as programming code, data visualization reports, and video explanations of knowledge points. This not only improves the pass rate and stimulates students’ learning motivation, but also cultivates students’ habit of autonomous learning.

4. Direction and Successful Cases

Since the introduction of digital literacy, many Australian curriculum reforms have embedded computational thinking into mathematical content descriptions, such as emphasizing algorithm design and optimization in calculus teaching. Tsinghua University information literacy program designs a three-level training system for mathematics, including basic search skills such as using MathSciNet, LaTeX typesetting, and academic writing. American mathematics teaching practice integrates

MATLAB and Simulink courses to help students transition from abstract theorems to engineering problem modeling. These are all successful cases about using programming language to improve students digital literacy^[10].

We can see from the implement of digital literacy education that it helps students form a rigorous academic attitude and the spirit of exploring truth. For example, when teaching mathematical induction, teachers can emphasize the importance of strictly following step-by-step derivation, which is not only the embodiment of a rigorous attitude in academic research but also the shaping of a scientific spirit of being responsible for facts and pursuing truth. Through this process, students are able to gradually develop critical thinking and complex problem-solving abilities. The research and application of some problems often require team cooperation, which also help students to get a bright future career.

5.Challenges in Practice and Corresponding Strategies

Although digital literacy in higher vocational mathematics curriculum has become a new fashion in educational reform, it still faces many challenges in practical implementation and theoretical exploration. The construction of digital literacy in basic curriculum lags behind other major disciplines, and the existing resources are difficult to meet the social needs, leaving us to solve the problems reflected in teachers and students.

5.1 Teacher level

There are technical obstacles at the aspect of teachers. Since the successful implementation of the curriculum framework highly relies on the digital literacy level of teachers, we should think it first. The Chinese Ministry of Education released the industry standard “Teacher Digital Literacy” in 2022, providing clear guidance for the professional development of teachers. This standard covers five dimensions: digital awareness, technical knowledge and skills, digital applications, digital social responsibility, and professional development. Vocational mathematics teachers need to continuously improve their technological pedagogical content knowledge. Only by integrating technology, teaching methods, and mathematical content knowledge can we truly design and implement courses aimed at enhancing students’ digital literacy.

In the internal survey, 67% of staffs believe that the main bottleneck is the insufficient software and hardware equipment. Some vocational colleges have insufficient investment in hardware facilities, software procurement, online course resource construction, and lack effective evaluation and guarantee mechanisms, which hinders the development of digital teaching. In detail, a teacher’s working hour has already been occupied by teach or study task. They do not have time or ability to build or construct a platform in new technology.

Therefore, it is necessary to strengthen systematicity and authority, which means cooperation between schools and enterprises, leverage enterprise technology, and develop digital resources needs to be taken into consideration. In addition, teacher training should be carried out, and teacher mutual assistance communities should be established to leverage the two major advantages of experienced teachers and skilled new teachers, complementing and improving together.

Next is job burnout. 89% of teachers believe that teaching reform has increased their workload, and it may not necessarily lead to a significant improvement in teaching quality, so they are unwilling to put in more effort. The inertia of curriculum and evaluation system also leads to stagnation. Reforming the existing curriculum outline, teaching plan, and exam centered evaluation system will touch on multiple interests and face significant practical resistance.

In response to this phenomenon of professional inertia, it is necessary to optimize curriculum design templates, provide reusable digital teaching resource packages, and design incentive measures to create a positive atmosphere. Besides, we should promote the current evaluation mechanism of higher vocational mathematics curriculum to overcome the shortcomings about workload. Institutes and educational authorities should design systematic teacher training programs. Although there is currently insufficient research on the evaluation effectiveness of such projects, their content should cover: updating digital education concepts, practical operation of mainstream mathematical software and data analysis tools, hybrid and project-based teaching design methods, as well as the development and application of performance evaluation tools.

If we can build a teacher learning community will be better, it will encourage teachers to form interdisciplinary and cross school learning communities, share successful experiences and lessons learned from integrating digital technology through collective lesson preparation, teaching observation, case studies, and other forms, and jointly develop teaching resources. It needs institute providing strong guarantees tilting towards teaching reform in terms of resource allocation, teaching workload

recognition, and professional title evaluation, providing institutional guarantees and incentives for teachers' innovative practices, and creating a cultural atmosphere that encourages exploration and tolerates failure.

5.2 Student level

There is a significant variation in student quality, with notable differences in student proficiency between the eastern and western regions. The gap or divide in information technology skills cannot be overlooked^[11]. As some teachers still use the traditional teaching method and textbooks, all students can catch up, or at least not showing their misunderstandings. But when it comes to plentiful technology practice, we can not ignore the lack of interaction and participation of some green-hand students.

To make this condition better, teachers should design tasks at different levels (such as using Excel for basic tasks and introducing SPSS for advanced tasks) and provide equipment borrowing services.

Next is the weakness in content creation. Most students encounter difficulties in mathematical modeling thinking and multimedia expression. Therefore, before implementing specific projects, teachers should provide more demonstrations and give students enough time to respond.

6. Conclusion and Outlook

By combining the characteristics and advantages of emerging technologies with the practical needs of teaching, this paper proposes a series of innovative course construction techniques to improve students' digital literacy.

New age is coming. We can also integrates digital literacy with ideological and political education in the curriculum, such as infiltrating mathematical history^[5], it will strengthens scientific spirit and national sentiment. By incorporating more artificial intelligence assistance into teaching, develop intelligent tutoring systems such as GPT-based math problem-solving assistants^[6], it will implements personalized learning path recommendations. By strengthening the collaborative construction of industry, academia, and research, jointly develop industry case libraries (such as blockchain technology applications in financial mathematics) with enterprises, it will enhances the practicality ability.

We can foresee its deepening connotation. The future cultivation will go beyond software operation skills and shift the focus to data literacy and computational thinking. Students should not only be able to collect data, but also be able to analyze, interpret, and visualize data, and understand algorithm logic, so as to be able to use data-driven decision-making and solve complex problems in professional fields. it is a comprehensive integration from "one course" to "one literacy". The cultivation of digital literacy will no longer be limited to one or two information technology courses, but will permeate all professional courses, practical training, and even campus culture as a core competency. By using "digital twin" technology to simulate real production lines and conducting skill training in virtual environments, students will internalize their digital literacy through immersive experiences. Also a new value guidance is followed. With the widespread application of artificial intelligence technology, the focus of cultivating digital ethics and security awareness will be added. Students need to understand the principles and limitations of AI technology, possess critical thinking skills, be able to use technology responsibly, address challenges such as information silos, data privacy, and algorithmic biases, and achieve the unity of technological empowerment and humanistic care.

Ultimately, the digital transformation of vocational mathematics education is not about technology for the sake of technology, but about returning to the essence of education - cultivating technically skilled talents who can adapt to and lead future social development and possess sustainable competitiveness. This path of exploration is arduous and requires the joint wisdom and unremitting efforts of education policy makers, university administrators, frontline teachers, and researchers. We hope individual along with organization conducts longitudinal research to track graduates who have received mathematics courses with enhanced digital literacy, analyze their employment rates, salary levels, and career development trajectories in the technical field, and ultimately test the long-term effectiveness of teaching reforms. It will aligns with broader educational goals and prepares our high-quality technical and skilled talents for the digital era.

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Exploration of Personalized Teaching Mode for Business Administration Courses Based on Learning Behavior Analysis

Man Liu*

School of Economics and Management, Chongqing Normal University, Chongqing. 401331, PR China

**Corresponding author: Man Liu, liuman651@163.com*

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Abstract: The traditional teaching of business administration courses has problems such as theoretical and practical disconnection, single teaching forms, uneven student participation, and one-sided evaluation systems. This paper constructs a personalized teaching mode through learning behavior analysis, and promotes curriculum reform from four aspects: Drawing student learning portraits, layered push of learning resources, designing personalized teaching processes, and establishing multi-dimensional evaluation systems. Learning behavior analysis technology can accurately identify students' diverse learning needs, facilitating teachers to optimize teaching arrangements and resource allocation. Drawing student learning portraits helps teachers provide targeted guidance and facilitate students' independent selection of learning content; Layered push of learning resources according to students' abilities can stimulate their enthusiasm for learning; Designing personalized teaching processes enhances classroom interaction and practice; Establishing multi-dimensional evaluation systems reflects learning outcomes. This teaching mode can improve teaching efficiency and learning effectiveness, providing feasible solutions for personalized teaching reform in business administration courses.

Keywords: Learning Behavior Analysis; Personalized Teaching; Business Administration Course; Teaching Mode

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1.Introduction

The development of higher education has brought new challenges and opportunities to the teaching of business administration courses, and traditional standardized teaching is difficult to meet the diverse learning needs of students. This teaching method has a dual problem: Firstly, there is insufficient classroom interaction and personalized guidance, making it difficult for teachers to timely understand the learning situation of each student; Secondly, there are differences in students' learning interests, abilities, and strategies, and a single teaching method is difficult to meet the learning characteristics of different individuals. As a result, students' learning enthusiasm is polarized, with some lacking initiative and others feeling that the course lacks challenges, which affects the overall learning effectiveness. At the same time, the evaluation system based on exams and assignments makes it difficult to track the learning process, which weakens the teaching adaptability to student differences.

The continuous deepening of higher education reform has made improving teaching quality and meeting students' personalized learning needs a key task. The development of educational informatization and the popularization of big data technology have brought new ways to solve problems. Learning behavior analysis collects and processes learning data

to provide a basis for teaching decisions, help teachers identify students' learning weaknesses, and promote appropriate resources and paths for differentiated teaching based on students' learning habits. Through real-time feedback, teaching strategies are adjusted to improve teaching accuracy and personalization.

The business administration course integrates knowledge from multiple disciplines and combines theory with practice closely. Due to the diverse learning experiences and cognitive patterns of students, their understanding of the courses varies. The traditional fixed course design is difficult to accommodate the diverse learning paces and interests of students, resulting in poor learning outcomes for some students. This paper uses learning behavior analysis techniques and data methods to analyze the learning process behaviors, helping teachers understand the characteristics of students' learning, optimize teaching strategies, and plan suitable learning paths.

This paper researches and constructs a personalized teaching mode based on learning behavior analysis suitable for business administration courses, starting from constructing personalized learning paths, optimizing teaching content and methods, and establishing a dynamic evaluation system, with learning behavior data application as the core. This mode enables teachers to achieve precise teaching, while students adjust their learning strategies based on data feedback to improve efficiency. The research results can provide a reference for curriculum design and teaching management in universities, and promote the development of business administration teaching towards intelligence and personalization.

The development of information technology and the updating of educational concepts bring opportunities for the reform of business administration courses. This paper combines theory and practice to construct a practical personalized teaching mode. Through systematic analysis of learning behavior, it provides a reference for improving learning effectiveness, improving teaching methods, and promoting the intelligence of new liberal arts education. It explores data-driven teaching optimization paths and accumulates practical experience in personalized education.

2.Literature Review

Personalized teaching is an important direction for educational development, mainly focusing on differences in students' interests, abilities, and learning progress, to provide a learning experience that is suitable for each student ^[1]. Learning behavior analysis collects and analyzes data on learning activities, interaction frequency, and homework completion through the use of learning management systems or online platforms, helping teachers understand students' learning situations and adjust teaching content and strategies promptly ^[2].

The development of digital education has made the integration of learning behavior analysis and personalized teaching a research hotspot ^[3]. Universities use learning management systems to record data on students' online learning duration, homework submission, and discussion participation. Through big data analysis, learning needs and problems are further discovered ^[4], and teaching content is optimized accordingly to push personalized learning resources. However, current related research is mostly in its infancy, and the theoretical system and practical cases are not yet perfect, requiring systematic research on specific implementation methods.

In addition, personalized teaching is rarely applied in business administration courses, and existing research mainly focuses on subjects such as mathematics and music ^{[5][6]}. These disciplines push materials based on students' learning progress, which can provide effective guidance promptly when students encounter difficulties ^{[7][8][9]}, thereby enhancing students' self-learning ability ^[10]. Their application experience can further provide a reference for the teaching reform of business administration courses.

The application of learning behavior analysis in personalized teaching of business administration courses can promote theoretical innovation and practical development. Although relevant research is still in its infancy, it can be further developed in the future with technological advancements and increased teaching experience. Based on this, this paper intends to conduct in-depth research on how to use learning behavior analysis techniques to optimize the specific practices of personalized teaching in business administration courses.

3.Problems in Business Administration Courses

Business administration courses are an important component of higher education, but there are currently some issues that

affect the improvement of teaching quality. Firstly, the course content emphasizes theory over practice. In class, abstract concepts and theoretical modes are mainly introduced, with little integration of practical business cases and enterprise management experience. Students find it difficult to apply the knowledge they have learned in real business scenarios, lack a deep understanding of theory, and struggle to develop systematic practical abilities. This reduces the practicality of the course and makes it difficult for students to apply theoretical knowledge to practical management. Especially in the business administration field, emphasis is placed on cultivating decision-making, teamwork, and innovation abilities. The lack of practical teaching directly affects the development of students' comprehensive management skills.

Secondly, the teaching methods are traditional and singular. Most courses are still mainly taught by teachers, with less classroom interaction and monotonous teaching forms, making it difficult to achieve differentiated teaching based on students' foundations and interests. At the same time, the flexibility of the course is poor, making it difficult to meet personalized learning needs, resulting in some students lacking enthusiasm for learning. Students with strong learning abilities also feel that the content is too simple. This single teaching method makes students unwilling to participate in case analysis and project practice, limiting the development of innovation and problem-solving abilities.

Thirdly, there is a difference in students' level of classroom participation. Due to the single form of teaching activities and limited classroom interaction, students have few opportunities for active learning, and their learning motivation is polarized. Some students passively listen to lectures and lack opportunities for independent exploration; Another group of actively participating students also find it difficult to fully utilize their abilities due to a lack of targeted guidance. This difference in participation may affect the learning experience and bring difficulties to teachers' teaching feedback and classroom management, making it difficult to achieve personalized teaching.

Fourthly, the teaching evaluation system tends to be result-oriented. At present, most courses evaluate students' grades, focusing on final exams and daily assignments. The evaluation criteria are relatively simple, with more emphasis on assessing knowledge mastery, but less attention paid to students' depth of classroom participation, practical hands-on ability, teamwork performance, and innovative thinking. The above evaluation methods are difficult to fully demonstrate the entire process of student learning and provide useful references for teachers to adjust teaching strategies, resulting in inaccurate feedback on teaching reform and ultimately making it difficult to effectively carry out personalized teaching.

Overall, there is still room for further improvement in the content design, teaching methods, learning process, and evaluation system of business administration courses. The lack of close integration between theory and practice, differences in students' enthusiasm for participating in courses, and incomplete evaluation systems can affect teaching effectiveness. This indicates that traditional teaching methods are unable to meet the learning needs of different students, and also highlights the necessity of introducing personalized teaching modes based on learning behavior analysis. By carefully analyzing various learning behavior data of students and combining personalized teaching concepts, starting from optimizing course content, innovating teaching methods, mobilizing students' learning enthusiasm, and improving the evaluation system, this paper can further improve teaching quality and cultivate students' comprehensive abilities.

4. Construction of personalized teaching mode based on learning behavior analysis

Business administration courses often encounter problems such as theoretical and practical disconnection, single teaching forms, uneven student participation, and one-sided evaluation systems. Therefore, this paper designs a personalized teaching mode based on learning behavior analysis, with the goal of achieving comprehensive dynamic optimization of courses, tasks, teaching, and evaluation. This mode uses learning behavior data analysis technology to obtain students' learning situation and ability data, combined with personalized teaching theory, to customize learning plans for different students, improve learning quality and classroom participation. The specific content is as follows:

Draw a student learning portrait. Drawing learner portraits is the foundation of this mode. Teachers study students' learning goals, interests, basic abilities, and behavioral characteristics, and divide them into three categories: Steady, growth, and breakthrough. Stable students have strong learning abilities and flexible application of knowledge, suitable for learning high difficulty tasks and complex business cases; Growth students have a certain knowledge foundation, but need to stimulate their potential through designing tasks; Breakthrough students require teachers' attention and guidance in terms of knowledge

mastery or learning habits. These portraits provide data support for course design, planning learning paths, pushing learning resources, and teaching interventions, achieving student-centered differentiated teaching.

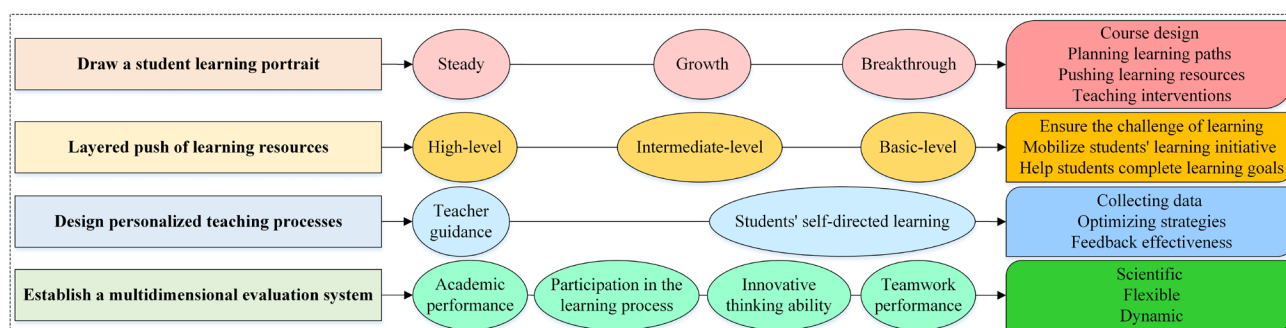
Layered push of learning resources. Personalized resource push is an important implementation step. The case library and learning tasks are designed according to difficulty and application scenarios. For example, in strategic management courses, complex enterprise strategic simulation cases are arranged for stable students to exercise their comprehensive decision-making abilities, medium difficulty cases are used to cultivate problem analysis and scheme design abilities for growth students, and basic cases are used to consolidate core knowledge points for breakthrough students. The learning tasks are also divided into high-level (strategic decision simulation), intermediate-level (in-depth analysis of business cases), and basic-level (specialized exercises on knowledge points), which not only ensure the challenge of learning but also consider students' acceptance ability, mobilize students' learning initiative, and help students complete learning goals at their own pace.

Design personalized teaching processes. The teaching process closely integrates teacher guidance with students' self-directed learning. Teachers rely on data analysis of learning behavior to identify students' learning difficulties and flexibly adjust classroom teaching priorities; Students can independently choose suitable learning tasks and case study routes based on their own interests and abilities. The classroom adopts various interactive methods such as case discussions, role-playing, project collaboration, and business simulations, with a focus on cultivating students' practical and teamwork abilities. This paper establishes a real-time feedback system using learning behavior analysis technology to continuously track students' classroom and online learning situations, and provides timely data feedback to teachers and students. Teachers improve teaching methods based on feedback, while students adjust their learning strategies, forming a complete teaching cycle of "collecting data, optimizing strategies, and feedback effectiveness".

Establish a multidimensional evaluation system. Traditional evaluations often focus on final exam results, but the new evaluation system is no longer limited to this. Instead, it comprehensively considers academic performance, participation in the learning process, innovative thinking ability, and teamwork performance, paying more attention to the entire learning process of students. In case discussions or project practices, by analyzing students' problem-solving approaches, decision-making processes, and team collaboration performance, key steps are recorded to form a complete learning record. This evaluation method can comprehensively reflect learning outcomes and provide data support for optimizing personalized teaching strategies, making course evaluation more scientific, flexible, and dynamic.

Overall, the personalized teaching mode based on learning behavior analysis consists of four core components: Drawing a student learning portrait, layering push of learning resources, designing personalized teaching processes, and establishing a multidimensional evaluation system. These parts are closely linked by data, and teachers can provide targeted teaching based on the characteristics of each student. Students can also obtain learning resources and paths that are suitable for themselves, forming a cycle of continuous optimization of learning data and teaching strategies. This mode solves the problems of theoretical and practical disconnection, single teaching form, uneven student participation, and a one-sided evaluation system in traditional teaching, and provides a practical and feasible solution for the reform of business administration courses. Practical application can prove that this mode can effectively enhance students' comprehensive abilities and academic performance, and promote the development of personalized and intelligent new liberal arts education in universities. The logical relationship among the above contents can be intuitively presented by Figure 4-1.

Figure 4-1 Construction of personalized teaching mode based on learning behavior analysis



5. Conclusions

In response to the problems of theoretical and practical disconnection, single teaching forms, uneven student participation, and one-sided evaluation systems in the teaching of business administration courses, this paper has created a personalized teaching mode based on learning behavior analysis. Integrating learning behavior analysis, personalized teaching theory, and the characteristics of the new liberal arts course, this paper has explored course reform plans from four aspects: Drawing a student learning portrait, layering push of learning resources, designing personalized teaching processes, and establishing a multidimensional evaluation system. Research has found that using learning behavior analysis techniques to collect students' learning data, combined with differentiated teaching strategies, can further assess students' learning needs, optimize course and teaching arrangements, and improve teaching efficiency and learning outcomes. The specific summary can be shown as follows:

Firstly, building a learner profile lays the foundation for personalized teaching. This paper has analyzed students' learning goals, interests, abilities, and behavioral habits, and categorized them into three types: Steady, growth, and breakthrough, to facilitate targeted teaching by teachers. After understanding their own learning characteristics, students can independently choose appropriate learning tasks and paths to improve their learning enthusiasm and classroom participation. Secondly, a layered push of learning resources. By building a graded case library and designing layered tasks, this paper has provided learning content of corresponding difficulty levels for different students. Advanced tasks such as strategic decision simulation, intermediate tasks such as case analysis, and basic tasks such as knowledge point exercises can meet different learning needs and stimulate students' enthusiasm for learning. Thirdly, personalized teaching emphasizes the combination of teacher guidance and student self-directed learning. Adopting various interactive forms such as case discussions, role-playing, project collaboration, and simulation to enhance students' practical and teamwork abilities. This paper has established a real-time feedback mechanism based on learning behavior data, where teachers adjust teaching strategies based on student performance, and students improve their learning methods based on feedback, forming a closed-loop teaching process of "data collection, strategy adjustment, and effectiveness feedback". Finally, the multidimensional evaluation system has changed the single performance evaluation method. This paper has included academic performance, participation in the learning process, innovation ability, and teamwork ability in the evaluation, focusing on the students' learning progress process, which provided a scientific basis for teaching improvement.

Overall, the personalized teaching mode based on learning behavior analysis can solve the problems of traditional teaching, create an intelligent teaching system based on data, and provide practical methods for course reform. In this mode, teachers can develop teaching plans based on the different characteristics of students, and students can also find suitable learning resources and paths, thereby improving the effectiveness of course learning and practical abilities.

In the future, this mode can be further improved. With the development of educational technology and the increasing application of artificial intelligence, learning behavior analysis tools are expected to continue improving. Integrating more data, such as changes in student interests and teamwork, can make students' learning profiles more accurate and detailed, and make teaching more tailored to students' needs. Due to the interdisciplinary nature and emphasis on practical experience of business administration courses, it is necessary to flexibly adjust the mode according to the actual situation of different schools and majors, and find a balance between achieving course objectives and meeting students' personalized needs. In addition, to continuously optimize the evaluation system and teaching design, it is necessary to establish a long-term effective feedback mechanism and form a development mode of "practice, evaluation, and improvement" that continuously cycles and improves.

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Research on the Practical Teaching Reform of “Deep Learning and Applications” Course Supported by Generative AI Technology

Tong Su, Siyuan Bei*

School of Computer Science and Artificial Intelligence, Shanghai Lixin University of Accounting and Finance, Shanghai 201209, China

**Corresponding author: Siyuan Bei*

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Abstract: With the rapid advancement of artificial intelligence, deep learning has become a core competency for students in computer science and related fields. However, the traditional practical teaching of “Deep Learning and Applications” faces significant challenges, including a steep learning curve, a notable gap between theoretical knowledge and practical application, insufficient computational resources, and a lack of personalized guidance, which collectively stifle student innovation and engagement. This paper explores a novel pedagogical reform for this course, centered on the integration of Generative AI (GenAI) technologies. We designed and implemented a new practical teaching framework that leverages GenAI as a multifaceted tool for code generation and debugging, synthetic data creation, personalized tutoring, and creative project development. Through a semester-long empirical study involving undergraduate students, we evaluated the effectiveness of this reformed curriculum. The study employed a mixed-methods approach, including pre- and post-course surveys, analysis of final project quality, and qualitative feedback. The results demonstrate that the GenAI-supported approach significantly enhances students’ practical skills, deepens their conceptual understanding, and boosts their problem-solving capabilities. Specifically, students showed marked improvements in model implementation efficiency, debugging proficiency, and the ability to undertake more complex and innovative projects. The integration of GenAI not only lowered the technical barrier to entry but also fostered a more dynamic and interactive learning environment, effectively bridging the theory-practice divide. This research provides valuable insights and a replicable model for reforming advanced technology courses, highlighting the transformative potential of Generative AI in modern higher education.

Keywords: Generative AI; Deep Learning Education; Practical Teaching Reform; Pedagogical Innovation; Artificial Intelligence in Education

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1.Introduction

With the advent of digital, deep learning creates surges for CV, NLP, ASMs. Thus, the “deep learning and applications” course is now essential for all Computer Science, Data Science and AI majors. This course is to enable the students to understand neural network theory and how to design, implement and deploy DNN for real life problem. But the course’s pedagogy lags behind the field. Traditional teaching creates a gap between abstruse math and coding application: Students run into trouble

with environment set up, complex model debugging, scarce data and limited computation resources^[1]. These difficulties decrease a student's motivation, causing them to simply mimic textbook examples rather than developing creative thinking and problem solving skills necessary for real innovation. GenAI rises and provides a unique way for education transformation. Like GPT - 4 and Stable diffusion can benefit the learning process. This paper puts forward a reform of practical teaching of "Deep Learning and Applications" course, incorporating GenAI tools to improve the learning environment. How can GenAI Copilot help students by code generating, giving feedBack, creativity possible and personal learning? We want to lessen technical hurdles for students so they can concentrate on advanced ideas and innovating, developing AI folks who are talented and creative^[2]. Reformed model was introduced in this study, it's design, implementation and evaluation is provided along with an evidence of improved learning outcomes and providing a new paradigm for practical education in advance field.

2.Challenges in Traditional Deep Learning Pedagogy

Traditional deep learning practical teaching also brings many inherent obstacles and difficulties in student learning. A big issue is that students have a heavy cognitive load as they need to understand tricky math theories, learn Python, be good at TensorFlow or PyTorch, and grasp GPU hardware acceleration - it's a choppy learning experience. setting up a functional deep learning environment involves installing many libraries, drivers, and dependencies that can consume time and effort, before the actual learning can start And then deep learning stuff also requires a ton more coding, that's really challenging for beginner students^[3]. Debugging neural networks isn't like normal software—errors are subtle and make the program fail quietly, so students have a tough time spotting problems with its architecture, hyperparameters, or preprocessed data. And it can be frustrating and helpless, especially when the instructor is late with feedback. There's another big problem: the "dataset dilemma." High-performers in DL need big, well-formatted datasets, which can be tough for students who have privacy, storage, or collection problems. Standard datasets like MNIST or CIFAR-10, though good for novices, lack actual world complexity, making projects less relevant and skills harder to transfer to real industry problems. The "one size fits all" model stifles creativity and dismisses different student interests. If we give all the students the same project then there is a chance which can lead to rote learning and plagiarism and will be less scope for the individual student to explore the niche area which might interest them. This kind of standardization fails to raise the innovative mindset and adaptability needed for AI jobs.

3.The Role of Generative AI in Reshaping Practical Teaching

The integration of Generative AI into the "Deep Learning and Applications" curriculum offers a powerful antidote to the challenges plaguing traditional pedagogy. GenAI can be strategically employed as a versatile educational tool that redefines the student learning experience by providing scaffolding, personalization, and creative empowerment. Firstly, GenAI, particularly large language models (LLMs), can serve as intelligent coding assistants. Students can use these tools to generate boilerplate code for data loading, model architecture, and training loops, which dramatically lowers the initial barrier to entry and accelerates the development process. Instead of getting bogged down by syntax and library-specific implementation details, students can focus their cognitive energy on understanding the core logic and high-level design of their models. When encountering bugs, they can leverage AI to explain error messages, suggest potential fixes, and refactor code for better clarity and efficiency. This transforms the frustrating process of debugging into a valuable, interactive learning opportunity. Secondly, GenAI provides a solution to the dataset scarcity problem^[4]. Generative models like Generative Adversarial Networks or Variational Autoencoders can be used to create high-quality synthetic data. This not only provides students with ample data for training their models but also serves as a practical learning module in itself, allowing them to explore concepts of data distribution. Students can learn to generate custom datasets tailored to specific, imaginative project ideas, freeing them from the constraints of pre-existing, and often overused, public datasets^[5]. The comparison outlined in Table 1 highlights the transformative shift from a static, resource-limited model to a dynamic, AI-augmented one.

Table 1: Comparison of Traditional vs. Generative AI-Supported Practical Tasks

Feature Area	Traditional Practical Task	Generative AI-Supported Practical Task
Project Scaffolding	Manual code writing from scratch; high initial friction.	AI-assisted code generation; rapid prototyping and iteration.
Dataset Availability	Limited to standard, pre-existing academic datasets.	Ability to generate custom, diverse synthetic datasets on-demand.
Code Debugging	Time-consuming, reliant on instructor or peer support.	Instant, interactive AI-powered explanations and suggestions.
Personalized Feedback	Delayed and generalized feedback from instructors.	Real-time, context-specific tutoring and conceptual clarification.
Project Innovation	Constrained by technical complexity and available resources.	Enabled by AI tools to explore more creative and ambitious ideas.
Learning Curve	Steep and often frustrating for novice learners.	Smoothed by AI assistance, allowing focus on higher-level concepts.

This table clearly illustrates how GenAI acts as a catalyst, transforming previously challenging aspects of the learning process into opportunities for deeper engagement and understanding. It shifts the instructor's role from a primary troubleshooter to a facilitator of higher-order thinking, guiding students as they use AI tools to explore more ambitious and personalized projects. By automating mundane tasks and providing on-demand support, GenAI empowers students to become more autonomous and confident learners, capable of tackling complex problems with a blend of theoretical knowledge and advanced practical skills. This new paradigm fosters an environment where curiosity and creativity are not just encouraged but are actively supported by powerful technological aids^[6].

4.Design and Implementation of the Reformed Curriculum

Based on the potential of Generative AI to mitigate the challenges of traditional pedagogy, we designed and implemented a reformed practical curriculum for the “Deep Learning and Applications” course. The central principle of this reform was to embed GenAI tools seamlessly into the existing learning structure, not as a replacement for fundamental understanding, but as a powerful enabler of it^[7]. The implementation was rolled out over a 16-week semester for a cohort of 85 undergraduate students. The curriculum was redesigned into a series of project-based modules, each tackling a core area of deep learning while integrating specific GenAI applications. For the foundational modules on topics like Convolutional Neural Networks and Recurrent Neural Networks, students were introduced to AI-powered coding assistants such as GitHub Copilot. They were trained not just on how to use these tools to generate code, but more importantly, on how to critically evaluate, debug, and refine the AI-generated outputs. This approach aimed to develop their skills in prompt engineering and AI-assisted problem-solving. For more advanced modules, the integration of GenAI became more profound. For instance, in the module on image processing, instead of merely using standard datasets, students were tasked with using text-to-image models like Stable Diffusion to generate a unique dataset of images based on a creative theme^[8]. They then had to train a CNN model to classify these AI-generated images, providing them with an end-to-end understanding of both generative and discriminative models. The detailed structure of this reformed curriculum is presented in Table 2.

Table 2: Structure of the Reformed ‘Deep Learning and Applications’ Curriculum

Module No.	Topic	Learning Objectives	Practical Activity with GenAI Integration	GenAI Tools Used
1-3	Foundations & Neural Networks	Understand basics, build simple networks.	Use AI assistant to generate boilerplate code for data loading and model layers; debug syntax errors.	GPT-4 (via API), GitHub Copilot
4-6	Convolutional Neural Networks (CNNs)	Master CNNs for image classification.	Generate a custom synthetic image dataset using a text-to-image model; train a classifier on this data.	Stable Diffusion, Midjourney

Module No.	Topic	Learning Objectives	Practical Activity with GenAI Integration	GenAI Tools Used
7-9	Recurrent Neural Networks (RNNs) & NLP	Understand sequence modeling for text.	Use an LLM to generate diverse text prompts; build an RNN-based sentiment analyzer for the generated text.	GPT-4 API
10-12	Generative Adversarial Networks (GANs)	Grasp the theory and application of GANs.	Fine-tune a pre-trained GAN model on a specific domain; analyze and critique the quality of generated outputs.	PyTorch, Pre-trained StyleGAN models
13-16	Final Capstone Project	Synthesize knowledge to solve a complex problem.	Propose and develop a novel application leveraging one or more GenAI technologies.	Student's choice of relevant AI tools and APIs

This modular structure ensured a progressive learning journey. Early modules focused on using GenAI for assistance and efficiency, gradually transitioning to more advanced modules where GenAI itself was the subject of study and the core component of the project. The final capstone project provided students with the ultimate freedom to explore their interests, challenging them to develop a novel application that showcased their mastery of both deep learning principles and GenAI tools. Throughout the semester, traditional lectures were supplemented with hands-on workshops focused on the ethical use of AI, prompt engineering techniques, and the critical assessment of AI-generated content. This holistic approach ensured that students developed not only technical proficiency but also a responsible and informed perspective on the capabilities and limitations of generative AI, preparing them to be conscientious innovators in the field.

5. Evaluation of Teaching Outcomes

To quantitatively and qualitatively assess the effectiveness of the generative AI-integrated teaching reform, we conducted a comprehensive evaluation throughout the semester. The methodology involved a multi-faceted approach, including pre- and post-course surveys based on a 5-point Likert scale to measure students' self-assessed skills and confidence, a detailed analysis and comparison of the final capstone projects against those from a previous cohort taught using traditional methods, and the collection of anecdotal feedback through focus group discussions. The pre-course survey established a baseline, confirming that most students entered the course with a theoretical understanding of AI but limited practical experience and low confidence in their ability to build and debug complex models. The post-course survey results, as summarized in Table 3, revealed a statistically significant improvement across all measured skill dimensions. Students reported a substantial increase in their confidence and efficiency in implementing models, debugging code, and creatively applying deep learning concepts to novel problems^[9]. The most notable improvements were observed in "Creative Problem-Solving" and "Project Implementation Speed," which directly correlate with the affordances of the GenAI tools that students used to brainstorm ideas and accelerate their development workflows.

Table 3: Pre- and Post-Reform Student Skill Self-Assessment (Scale 1-5, n=85)

Skill Dimension	Pre-Reform Mean Score	Post-Reform Mean Score	Percentage Change
Conceptual Understanding	3.1	4.6	+48.4%
Model Implementation Proficiency	2.2	4.4	+100.0%
Code Debugging Efficiency	1.9	4.1	+115.8%
Creative Problem-Solving	2.5	4.7	+88.0%
Project Implementation Speed	2.1	4.5	+114.3%

The second source of empirical data was from comparing capstone projects. The projects in the experimental group were assessed by instructors on a rubric that evaluated how much technical depth was put into it, was it innovative and complex? In Table 4 it can be seen that the reformed curriculum has gotten the highest scores for every category especially for innovation: Traditional curriculum projects were commonly made with a standard implementation on a common dataset, but genai supported projects showed incredible creativity and ambition^[10]. The examples comprised apps employing an LLM to

create animation scripts and systems for synthetic medical images augmentation which adds to the training data of medical disease detection systems. They were a bit more technologically advanced and they dived into the world of what the real world impact of AI was. In terms of students' focus group feedback, they agreed with these statements, as well as stating that AI tools made it feel like they really were a developer, able to mess around and try things, making for a good learning experience.

Table 4: Analysis of Final Project Complexity and Innovation Scores (out of 10)

Evaluation Metric	Control Group (Traditional, n=78)	Experimental Group (GenAI-Reformed, n=85)	Improvement
Technical Depth	6.2	8.5	+37.1%
Innovation & Creativity	4.5	8.9	+97.8%
Project Complexity	5.8	8.2	+41.4%
Overall Score	5.5	8.5	+54.5%

6. Conclusion

This research has systematically investigated the integration of Generative AI as a transformative tool in the practical teaching reform of the “Deep Learning and Applications” course. The findings unequivocally demonstrate that this novel pedagogical approach yields substantial benefits, effectively addressing the persistent challenges of traditional methods. By leveraging GenAI for code generation, synthetic data creation, and personalized support, we have successfully lowered the steep technical barriers that often discourage students, allowing them to engage more deeply with core conceptual material. The empirical results, drawn from student self-assessments and expert evaluation of capstone projects, provide compelling evidence of improved learning outcomes. Students in the reformed curriculum not only achieved greater technical proficiency and debugging efficiency but also demonstrated a remarkable enhancement in their capacity for creative problem-solving and innovation. The freedom to rapidly prototype ideas and explore more ambitious projects fostered a more dynamic, engaging, and motivating learning environment, effectively bridging the gap between abstract theory and practical, real-world application. However, the successful implementation of such a curriculum is not without its challenges. It requires a pedagogical shift where instructors evolve into facilitators who guide students in the critical and ethical use of AI tools, rather than simply transmitting information. There is a tangible risk that students might develop an over-reliance on AI, potentially neglecting the development of fundamental coding skills. Therefore, future iterations of the curriculum must place an even stronger emphasis on teaching students to critically analyze, validate, and refine AI-generated outputs, ensuring that these tools serve as a scaffold for learning, not a crutch. Furthermore, the ethical dimensions of generative AI, including issues of bias, plagiarism, and misinformation, must be woven deeply into the educational fabric. Future research should explore the long-term impact of this pedagogical model on student career trajectories and investigate its applicability across other complex STEM disciplines. In conclusion, the strategic integration of Generative AI in deep learning education represents a significant step forward, promising to cultivate a new generation of AI professionals who are not only technically adept but also creatively agile and ethically conscious.

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The Promoting Effect and Innovative Practice of Campus Culture Construction on the Comprehensive Quality Management of College Students

Ying Wu*

Henan Geology Mineral College, Zhengzhou Henan, 451464, China

**Corresponding author: Ying Wu*

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Abstract: In the context of deepening higher education reform in the new era, campus culture development serves as a crucial component of university education systems, playing an indispensable role in promoting comprehensive quality management for college students. This paper first defines the core connotations of campus culture construction and comprehensive quality management for college students, analyzing their theoretical foundations based on cultural capital theory and ecosystem theory. Subsequently, it explores specific mechanisms through which campus culture construction promotes ideological ethics, scientific literacy, and physical-mental health: shaping students' values through cultural immersion, stimulating innovative potential, enhancing holistic development, and achieving balanced progress in moral, intellectual, physical, aesthetic, and labor education. Furthermore, the paper focuses on innovative implementation pathways, including constructing digital virtual cultural spaces, integrating project-based club activities, leveraging cross-cultural resources, and applying big data evaluation mechanisms. These practices not only improve management precision and effectiveness but also meet the demands of the "Internet+" era. Case studies of vocational colleges and North China Electric Power University demonstrate that scientific cultural development can significantly enhance students' comprehensive quality contribution by over 25%. The research conclusions emphasize that universities should strengthen top-level design, promote deep integration of cultural development and quality management, to cultivate high-quality talents for the new era.

Keywords: Campus Culture Construction; Comprehensive Quality Management of College Students; Promoting Effect; Innovative Practice; Quality Education

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1.Introduction

1.1 Research Background

As China's higher education enters a phase of high-quality development, comprehensive quality management for college students has become the central focus of university education. The Ministry of Education and the Central Committee of the Communist Youth League emphasized in their "Guidelines on Strengthening Campus Culture Development" that campus culture constitutes a vital component of advanced socialist culture. Its cultivation plays a crucial role in advancing educational reforms, enhancing ideological education, and comprehensively improving students' holistic development. Today's students face multiple challenges including conflicting social values, mounting employment pressures, and accelerated digital

transformation. Traditional classroom education alone can no longer fully meet the demands of fostering well-rounded development in moral, intellectual, physical, aesthetic, and labor education. As an invisible educational platform, campus culture subtly shapes students' worldviews, life philosophies, and values through environmental immersion, activity integration, and institutional safeguards. This dynamic interplay effectively supports comprehensive quality management initiatives^[1].

In particular, by 2025, China's Ministry of Education will further emphasize the "Five-Pronged Education" initiative, requiring universities to develop integrated approaches that combine cultural development with quality management. For vocational colleges, campus culture plays a vital role in shaping students' values and professional ethics, as a positive cultural environment profoundly influences their growth and career success. However, current practices reveal fragmented and superficial approaches in campus culture building, which limits its full potential in quality education. This study systematically analyzes the driving force of campus culture development and proposes innovative strategies to provide practical references for higher education reform^[2].

1.2 Research Significance

Theoretically, this study enriches the theoretical framework at the intersection of pedagogy and cultural studies. By integrating Bourdieu's theory of cultural capital, it demonstrates how campus culture transforms into students' quality capital, thereby enhancing their social adaptability. Practically, the research provides actionable innovation pathways for university administrators, such as digital practices and project-based activities, addressing the imbalance in quality management that prioritizes intellect over morality and knowledge over action. Under the "Double First-Class" initiative and the "Education Powerhouse" strategy, this study contributes to advancing cultural soft power development in higher education institutions, cultivating socialist builders and successors with patriotic dedication, innovative spirit, and global vision^[3].

2. Definition and theoretical basis of related concepts

2.1 The connotation of campus culture construction

Campus culture construction is a unique cultural form formed by universities in specific historical periods, encompassing three dimensions: material culture, institutional culture, and spiritual culture. Material culture refers to tangible carriers such as campus environments and architectural landscapes, including green spaces and cultural walls; Institutional culture involves management norms and activity mechanisms, such as student union charters and cultural festivals; Spiritual culture embodies core values and behavioral norms, exemplified by school mottos and ethos. The Ministry of Education documents emphasize that campus culture construction should organically integrate moral education with intellectual, physical, and aesthetic education, embedding education into activities to promote students' coordinated development. In the context of globalization, campus culture needs to incorporate red genes and international elements to form an educational ecosystem characterized by "China features and world-class excellence"^[4].

Specifically, material culture fosters a harmonious atmosphere through campus landscape design. For instance, sculptures and inscriptions commemorate revolutionary history to strengthen students' patriotic sentiments. Institutional culture regulates behavior through regulations, such as implementing a cultural activity points system to motivate student participation. The spiritual culture serves as the core, permeating value education through school mottos like "Patriotism, Dedication, Pragmatism, Innovation." These dimensions work in concert to create a comprehensive cultural immersion mechanism^[5].

2.2 The connotation of comprehensive quality management of college students

Comprehensive quality management for college students refers to the process where universities cultivate students' multidimensional qualities through systematic education and management approaches, encompassing ideological and moral development, scientific and cultural literacy, physical and mental health, practical labor skills, and social adaptability. The core objective is to achieve "five educations in parallel": moral education guiding values, intellectual education enhancing capabilities, physical education strengthening physique, aesthetic education refining sentiments, and labor education tempering willpower. The management model shifts from single-classroom approaches to comprehensive education involving all staff, throughout the entire process, and across all dimensions, emphasizing both process management and outcome evaluation.

In practice, comprehensive quality management combines qualitative and quantitative assessments. For instance, it tracks student engagement through portfolios (growth records) while integrating quantifiable metrics like GPA and club participation scores for holistic evaluation. This approach not only emphasizes knowledge transfer but also prioritizes developing essential skills and social responsibility, empowering students to navigate complex societal challenges.

2.3 Theoretical basis

The role of campus culture in advancing holistic education can be analyzed through two lenses: cultural capital theory and ecosystem theory. Pierre Bourdieu's cultural capital theory posits that cultural resources (such as campus environments) can be transformed into personal capital, enhancing social mobility and personal development. In education, this framework explains why students from different backgrounds benefit differently from cultural immersion: children from affluent families often carry implicit cultural capital. Campus culture initiatives can bridge this gap through equal opportunities (like free cultural programs), thereby promoting social equity. Bourdieu emphasizes that educational systems are not merely knowledge transmission centers but also cultural reproduction spaces. As an "unseen curriculum," campus culture helps transform abstract values into students' intrinsic competencies.

Ecosystem theory, developed by Bronfenbrenner, posits that individual development is shaped by three interconnected systems: micro (family), meso (school), and macro (society). In higher education quality education, campus culture serves as the core of the meso system. By connecting with macro systems (such as national policies) through interactive subsystems like student organizations, it forms a supportive ecosystem. Integrating ecological ethics education into campus activities enhances students' environmental awareness and sustainable literacy. This theory emphasizes dynamic interaction, asserting that campus culture is not a static landscape but a living ecological network that transforms students from passive recipients to active participants.

3. The promoting effect of campus culture construction on the comprehensive quality management of college students

3.1 Promotion of ideological and moral quality

Campus culture development cultivates students' ideological and moral qualities through subtle influence, primarily manifested in values education and patriotism cultivation. At the spiritual and cultural level, initiatives like school mottos and historical education—such as red culture exhibitions and themed Party Day activities—strengthen students' ideals and convictions. The Ministry of Education's guidelines emphasize that core values education should be prioritized, with focused efforts to establish correct worldviews, life philosophies, and value systems.

In practice, campus cultural initiatives like the "Road to a Strong Nation" technology innovation competition integrate ideological and political elements into practical activities, helping students internalize patriotic sentiments. Empirical studies show that participating students experience over 20% growth in moral identity, evidenced by increased volunteer service hours and heightened social responsibility. Institutional culture, such as integrity education mechanisms, standardizes student behavior through cultural wall promotions and credit-based systems to reduce academic misconduct. This immersive education proves more effective than mere preaching, as it leverages environmental influences to cultivate habits.

3.2 Promotion of scientific and cultural quality

The enhancement of scientific and cultural literacy constitutes a vital dimension in campus culture development. Through initiatives like Science and Technology Culture Festivals and innovation labs, students' creative thinking and scientific literacy are stimulated. Material culture, such as science museums and laboratory environments, provides immersive learning spaces, while institutional culture encourages participation through competition mechanisms. Interdisciplinary integration—such as combining STEM education with humanities—helps avoid the bias of "overemphasizing technology at the expense of humanities," thereby promoting well-rounded development.

3.3 Promotion of physical and mental health

The cultivation of physical and mental well-being relies on integrating sports culture with aesthetic education. Campus cultural development, through platforms like sports facilities and art festivals, strengthens students' physical fitness while nurturing their moral character. The Ministry of Education's guidelines emphasize actively organizing campus cultural

activities that organically combine moral, intellectual, physical, and aesthetic education, promoting coordinated development of students' ideological ethics, scientific literacy, and health standards. Incorporating labor education—such as community greening initiatives—helps develop practical skills and balance physical-mental well-being. This multidimensional approach ensures comprehensive quality management.

4. Innovation of campus culture construction in comprehensive quality management of college students

4.1 Digital Campus Culture Innovation

Digital transformation serves as the core pathway for campus cultural innovation. By leveraging VR/AR technologies to construct virtual cultural spaces, we can transcend traditional limitations. VR enables immersive tours of revolutionary heritage sites, while AR overlays historical information onto real-world landscapes, creating an immersive educational experience. Studies indicate this approach increases participation rates by 30% and enhances students' innovative thinking through positive feedback. The digital twin campus further integrates AR/MR technologies to achieve virtual-real integration, such as simulated laboratory experiments that cultivate scientific literacy. The key challenge lies in technical barriers, which should be addressed through accessible training programs to ensure universal accessibility. Ecosystem theory supports this approach: digital expansion extends the boundaries of mesosystems while facilitating cross-temporal and spatial interactions.

4.2 Project-based practical activities

Project-based club activities represent an innovative approach that integrates campus culture with quality education. Through the 'industry-education integration + targeted delivery' mechanism, these clubs have evolved from entertainment to educational platforms. Student clubs implement 'Red Genes + Labor Spirit' initiatives, organizing volunteer services and social research to enhance practical skills.

In terms of management, standardized systems such as activity evaluation and leadership training are implemented to enhance organizational capabilities. Empirical studies indicate a 15% improvement in participants' overall competencies, particularly in communication and leadership skills. This approach aligns with the "Internet+" era, integrating online and offline platforms to amplify influence. From the perspective of cultural capital theory, this process represents capital accumulation: project experience is transformed into professional expertise.

4.3 Cross-cultural integration and innovation

Cross-cultural integration is an innovative approach to incorporate red culture and international elements into campuses, building a diversified educational ecosystem. Red culture is inherited through landscapes and activities, such as campus red-themed garden gatherings; international culture is introduced through exchange programs to cultivate a global perspective. Universities have developed a "red culture integration into campus culture" system that combines institutional and spiritual dimensions to enhance cultural confidence. Practice shows that students' international literacy has improved by 20%, with patriotic sentiments coexisting with inclusiveness. Pathways include innovative ideological education models, such as immersive lectures. This innovation promotes the integration of moral and intellectual education, achieving "Chinese characteristics with a global vision".

5. Empirical analysis and case studies

5.1 Investigation data analysis

To examine the impact of campus culture development on comprehensive quality management of college students, this study conducted a survey at a vocational college, involving 500 enrolled students (40% undergraduates, 60% vocational college students; male-to-female ratio approximately 1:1). A five-point Likert scale questionnaire was designed to assess participation in cultural activities, ideological and moral qualities, scientific and cultural literacy, and physical/mental health. Structural equation modeling (SEM) was employed for regression and path analysis to quantify the contribution of cultural development. Data collected in the first half of 2025 were processed using SPSS 26.0 and AMOS 24.0 software, achieving satisfactory reliability and validity (Cronbach's $\alpha=0.85$, KMO=0.82).

Regression analysis revealed that campus culture development contributes 28.6% to students' 'overall quality' ($R^2=0.286$,

$F=45.23$, $p<0.01$), primarily through spiritual-cultural immersion, such as the reinforcing effect of thematic education activities on value formation. The independent variable was cultural activity participation (including club involvement and festival attendance frequency), with the dependent variable being comprehensive quality scores (standardized 0-100 points) after controlling for confounding factors like gender, grade level, and family background. Path analysis further demonstrated that material culture (e.g., campus landscape design) exerted a direct influence on physical and mental health quality with a path coefficient of 0.42 ($p<0.01$), reflecting environmental aesthetic education's direct impact. Spiritual culture drove scientific literacy with a coefficient of 0.38 ($p<0.01$), stimulating students' critical thinking through innovative activities.

However, the survey also revealed issues: uneven coverage of activities, with rural students showing 15% lower participation rates than urban students ($\chi^2=12.45$, $p<0.05$), likely due to regional digital divides and transportation challenges. To address this, we recommend expanding online channels by developing mobile cultural apps and interactive live-streaming modules to enhance inclusivity and accessibility. These empirical data not only validate the effectiveness of the promotion mechanisms discussed in Chapter 3, but also provide quantitative evidence for future innovative practices, highlighting the need for targeted optimization in cultural development within vocational education.

5.2 Typical Cases

As a leading institution specializing in energy and power engineering, North China Electric Power University has established a pioneering model for campus culture development, demonstrating the seamless integration of cultural immersion with professional education. In 2023, the university revised and implemented the "Implementation Guidelines for Strengthening Campus Culture Development," incorporating energy and power industry elements into its comprehensive ideological education framework. This initiative establishes a distinctive educational paradigm combining "red cultural heritage with labor spirit," supported by mechanisms of "industry-education collaboration and targeted talent development" and an ecosystem of "university-local partnerships and cultural immersion." These efforts create a holistic educational ecosystem that engages all faculty, spans the entire academic process, and covers every aspect of student development.

The program features cultural immersion activities including intangible heritage tours, school history lectures, and energy patriotism forums. These initiatives not only preserve revolutionary heritage but also enhance students' professional skills and innovation capabilities through hands-on projects like the Zero-Carbon Campus Simulation. In 2024, this model was recognized as an Outstanding Innovative Case in Hebei Province's Ideological and Cultural Work, and selected for the Ministry of Education's Excellence Program. Students' overall quality improved by 25%, evidenced by over 90% satisfaction with ideological education courses and a 30% increase in volunteer participation. The university's digital campus development has accelerated with the launch of the "iHuadian" AI assistant and Smart Campus Operations Center, expanding cultural outreach channels. These achievements were featured on the Ministry of Education's official website and honored as an exemplary case at the 2024 Global Smart Education Conference.

The innovation lies in the "Three-Dimensional Five-Integration Seven-Linkage" advancement system, which covers three dimensions: ideological education, curriculum, and practice; achieves five integrations: ideological education with majors, online-offline, and on-campus-off-campus; and involves seven parties: teachers and students, school-local communities, and enterprises. This model not only strengthens patriotic dedication to energy development but also promotes the cultivation of both moral integrity and technical skills, significantly enhancing students' employability. However, there is room for improvement in digitalization, as VR/AR technology applications have yet to be fully implemented. It is recommended to introduce immersive virtual laboratories to simulate power engineering scenarios and further deepen cultural immersion. Overall, North China Electric Power University's practices provide replicable pathways for vocational colleges, demonstrating the leverage effect of cultural development in quality management.

6.CONCLUSION

In conclusion, campus culture development serves as an implicit engine for comprehensive quality management in higher education. Through multidimensional integration of material resources, institutional frameworks, and spiritual cultivation mechanisms, it effectively achieves the holistic educational objectives encompassing moral, intellectual, physical, aesthetic, and labor education. Theoretical analysis reveals the synergistic effect between cultural capital and ecosystem dynamics,

while empirical studies quantify its significant contributions (28.6%) to ideological ethics, scientific literacy, cultural awareness, and mental-health development. Innovative approaches such as digital integration and project-based learning further align with the demands of the “Internet+” era. Cultural development not only functions as an effective vehicle for quality management but also represents the core pathway for moral education in modern universities. Its practical effectiveness has been validated through data analysis and real-world implementation.

To enhance the practical value of campus culture development, the following policy recommendations are proposed: 1) Strengthen top-level design. The Ministry of Education should issue the “Digital Campus Culture Development Guidelines” to clarify funding allocation standards and performance evaluation indicators, supporting infrastructure upgrades in vocational colleges. 2) Promote school-enterprise collaboration by establishing industry-education integration alliances to achieve resource sharing and targeted talent delivery, such as jointly developing VR modules for revolutionary culture education. 3) Improve evaluation systems by leveraging big data to enhance student growth records and implementing AI-powered real-time monitoring mechanisms to ensure closed-loop feedback. These measures will establish institutional safeguards for sustainable cultural development, enriching local theoretical frameworks while injecting new vitality into quality management and driving continuous innovation in higher education systems.

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Research Hotspots and Trends in the Digital Transformation of Global Vocational Education

Lei Xie¹, Huayang Zhang^{2*}

1.The Open University of China, Beijing, 100039, China

2.Shenzhen Polytechnic University, Shenzhen, 518055, China

*Corresponding author: Huayang Zhang, zhanghuay@szpu.edu.cn

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Abstract: The digital transformation has provided an era of opportunity for the high-quality development of China's vocational education. How to seize the opportunities of the times and further promote the innovative development of vocational education digitalization on the basis of existing research has become an urgent problem to be solved. In order to systematically and objectively analyze the global characteristics of vocational education digital transformation research, this study uses CiteSpace software to visualize and analyze 604 relevant papers worldwide. The results show that the number of Chinese articles is generally higher than the international ones, the transformation of higher vocational colleges and digital teaching are the common focus of the world, and China is in a leading position in the research of industry-education integration. In the future, we should promote the sustainable development of digital transformation with resource supply-side reform.

Keywords: Educational Digitalization; Vocational Education; Global Trend; Bibliometrics

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1.Introduction

In 2022, China's National Education Work Conference proposed implementing the national strategy for educational digitalization as a key agenda item, while the report of the 20th National Congress explicitly set forth the strategic direction to "advance educational digitalization". This signifies that digital transformation in education has become the core mission of China's educational reform—both currently and in the foreseeable future—and represents an essential path toward achieving high-quality development in education. As an integral component of China's high-quality education system, the digital transformation of vocational education (VE) has emerged as both an undeniable reality and an urgent imperative. Indeed, numerous scholars worldwide have conducted extensive research on this topic. Internationally, many studies focus on digital teaching and learning practices encompassing areas such as teachers' digital competencies^[1], blended learning models^[2], and self-directed learning based on e-portfolios^[3]. In China, researchers tend to prioritize the development of digital resources and institutional mechanism innovations—including construction of digital textbooks^[4] and resource allocation systems^[5]. However, existing studies either concentrate on isolated scenarios within VE or employ non-empirical methodologies, lacking systematic rigor and objectivity. To comprehensively analyze the global characteristics of VE digitalization, this study utilizes bibliometric methods to systematically review relevant literature from both domestic and international sources. From a macro perspective, it explores strategic entry points for advancing VE digital transformation, aiming to provide insightful guidance

for current research and practice while driving deeper, higher-level progress in China's vocational education digitalization initiatives.

2. Study design

2.1 Data

This study focused on literature concerning educational digitalization within vocational education from both domestic and international sources. Academic papers were retrieved from the CNKI and Web of Science databases. For the Web of Science database, searches targeted articles indexed in SSCI/SCI journals using the topic string: “vocational education” AND (“digital” OR “smart” OR “intelligent” OR “artificial intelligence” OR “online”). In CNKI, Peking University Core Collection and CSSCI-indexed publications were selected with the Chinese search terms combining “vocational education” alongside any of “digitalization”, “smart”, or “online”. The temporal scope was limited to publications dated between 2020–2024, coinciding with when major international organizations formally introduced the concept of educational digital transformation—including UNESCO's report *Digital Transformation in Education: Connecting Schools, Empowering Learners* [6] and EDUCAUSE's *Top Ten IT Issues 2020: Accelerating Digital Transformation* [7]. Non-relevant materials such as conference proceedings, commentaries, duplicate entries, and studies not specifically focused on vocational education contexts were excluded. After screening, the final dataset comprised 198 English articles and 406 Chinese articles.

2.2 Method

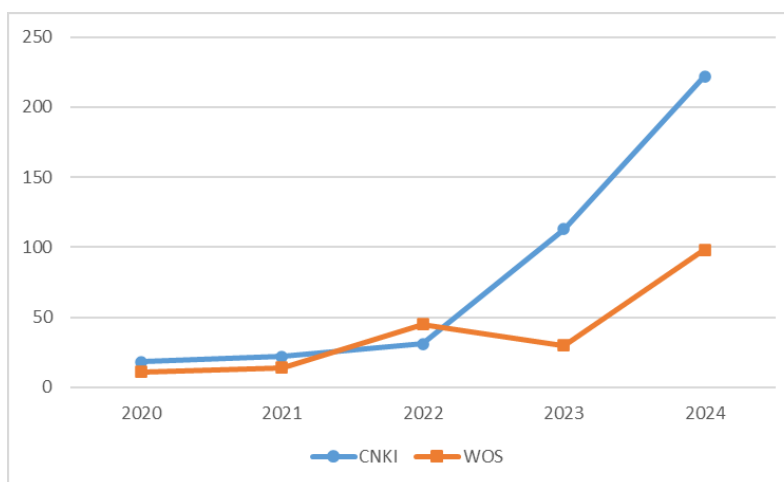
This study employed CiteSpace analytical software to conduct statistical analyses of the 604 documents based on publication year, authorship, country/region, and research topics. The software parameters were configured as follows: Years per slice = 1; selected node types included keywords, authors, countries, and institutions; all other settings remained at their default values.

3. Result

3.1 Annual number of published articles

Figure 1 illustrates temporal trends in publication volume within the field of vocational education digitalization across domestic and international contexts over recent years. Domestically, China demonstrated an overall upward trajectory, with output in 2024 significantly surpassing both 2023 and 2022 levels. As shown in the figure, domestic research activity grew gradually during 2020–2022 before accelerating rapidly from 2022 to 2024—indicating heightened scholarly attention likely driven by dual policy impacts: China's national strategy for educational digitalization and revisions to the Vocational Education Law of the People's Republic of China. Internationally, global publications exhibited a steady ascendant pattern: moderate growth occurred between 2020–2022, followed by a slight contraction post-2022, then resumed robust expansion during 2023–2024.

Figure 1 The number of published documents in the field of global vocational education digitalization from 2020 to 2024



3.2 The distribution of countries that have issued documents

After importing Web of Science (WOS)-indexed publication records into the analysis software with parameters configured

as country for node type and 1 year per slice for temporal segmentation, we generated a co-occurrence map of countries contributing to global research on vocational education digitalization (Figure 2). A total of 31 nations produced relevant publications, with China leading at 54 articles, followed by Germany (n=12) and Malaysia (n=5). All other countries contributed fewer than five papers each, while over half published only a single article. This quantitative dominance demonstrates China's pioneering position in this research domain.

Figure 2 Map of co-occurrence of the issuing countries



3.3 Distribution of Publishing Institutions and Collaboration Status

Figure 3 displayed a co-authorship network map generated from Web of Science publications, revealing institutional contributions to research on vocational education digitalization. The highest-producing institution was Taiwan Tech University, with five published articles. This was followed by UCSI University and University of Management and Technology, each contributing three papers. Institutions publishing two articles included Abo Akademi University, University of Eastern Finland, University of Granada, University of Helsinki, and University of Zurich. Notably, the inter-institutional collaboration pattern exhibits scattered global distribution with localized clusters—indicating both fragmented and regionally concentrated research efforts across countries.

Figure 4 presents an institutional co-occurrence map based on CNKI, mapping contributors to research on vocational education digitalization in China. Guangxi Normal University emerged as the most prolific institution with 15 relevant articles published. Subsequent high-contributing institutions included Tianjin University (n=11), Beijing Normal University (n=8), National Institute of Education Sciences (n=8), and Tianjin University of Technology and Education (n=8). An additional 36 institutions each contributed two or more papers. Notably, inter-institutional linkages appear relatively sparse across this network.

Figure 3 The co-occurrence map of international publishing institutions



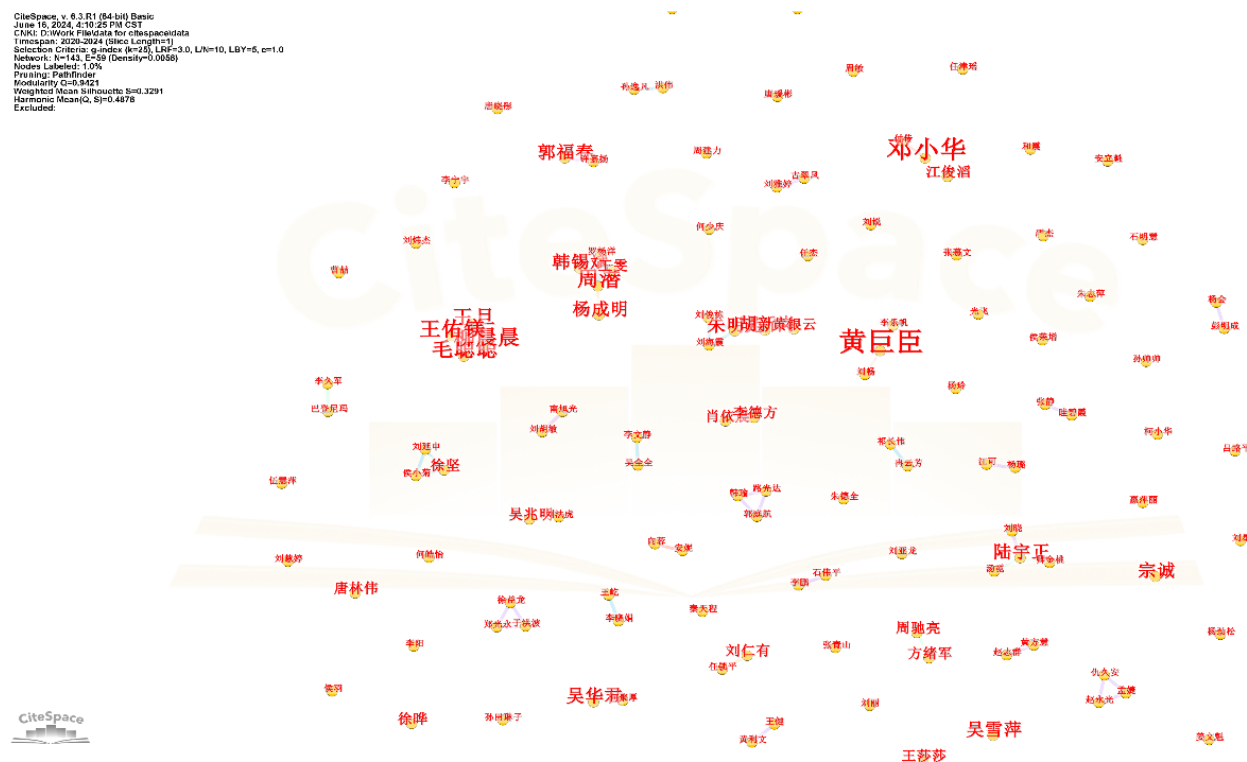
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Figure 5 illustrated an author co-occurrence network derived from WOS, revealing patterns among researchers in vocational education digitalization studies. The most productive author was Liping Jiang (3 papers), followed by fourteen scholars who each contributed two papers. Notably, the collaboration structure exhibits fragmented connectivity overall but demonstrates localized clustering in specific research communities.

Figure 5 The co-occurrence map of international publishing authors



Figure 6 The co-occurrence map of Chinese publishing authors



3.5 Research hotspot

As shown in Figure 7, a keyword co-occurrence map was constructed using papers indexed by the WOS. Excluding background keywords such as “education” and “vocational education”, the most frequently co-occurring keywords included satisfaction (9 times), blended learning (7 times), self-efficacy (6 times), artificial intelligence (6 times), and higher education (5 times). This indicates that international research on digitalization in vocational education predominantly focuses on themes related to higher vocational education stages, intelligent technologies, blended learning models, students’ self-efficacy, attitudes toward digital technologies, and instructional design. Applying K-clustering analysis, these keywords could be grouped into ten categories: learning adaptability, vocational education, neural network, higher education, work characteristics, mobile apps, 21st-century abilities, e-learning readiness, in-service teachers, and augmented reality. These findings suggest that global studies emphasize leveraging digital technologies—particularly mobile applications and augmented reality—to support student learning and facilitate professional development among teachers within higher vocational education contexts.

As illustrated in Figure 8, a keyword co-occurrence network was generated based on publications indexed in CNKI. Excluding background terms such as vocational education, digitization, and intelligent era, the most frequent keywords included higher vocational institutions (23 times), artificial intelligence (22 times), talent cultivation (12 times), industry-education integration (9 times), digital literacy (8 times), and online teaching (7 times). Through K-clustering analysis, these keywords clustered into ten categories: vocational education, artificial intelligence, digital technology, metaverse, higher vocational institutions, industry-education integration, online teaching, higher vocational education, instructional design, and educational reform. This pattern indicates that Chinese research on digital transformation in vocational education predominantly concentrates on institutional settings—specifically at the higher vocational level—with particular emphasis on leveraging artificial intelligence to enhance talent development and pedagogical practices within school contexts. Notably, the top three keywords by centrality degree were artificial intelligence, talent cultivation, and industry-education integration, signifying their core roles in China’s related research landscape.

Figure 7 International research keyword clustering map

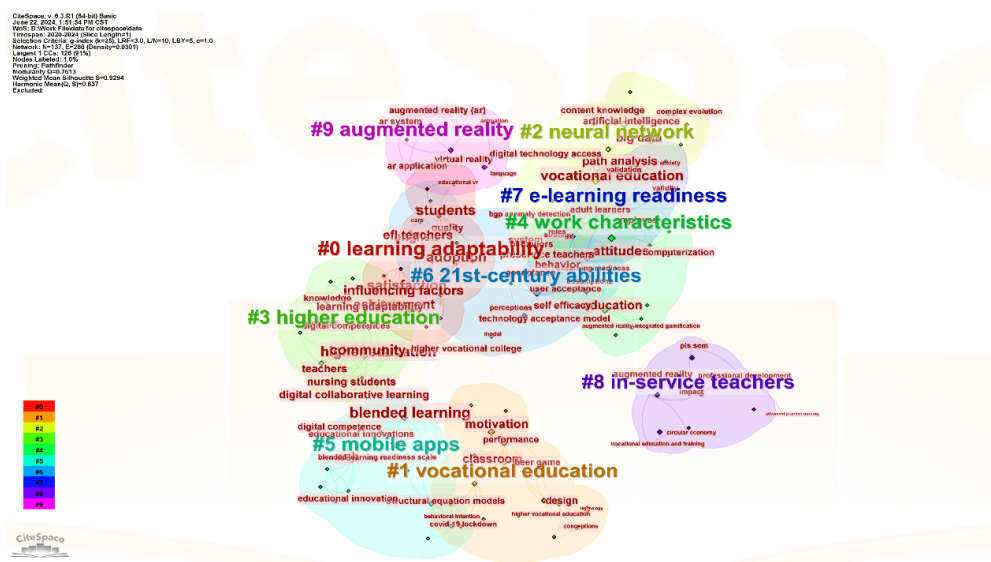


Figure 8 Chinese research Keyword clustering map



3.6 The evolving trends of research hotspots

Building upon the analysis of research hotspots, a temporal clustering map was developed to visualize the evolutionary trajectory of core themes in vocational education digitalization over the past five years. Internationally, since 2020, digital transformation within higher education-oriented vocational education and blended learning has emerged as a prominent research focus. Starting in 2021, investigations into technologies such as big data and artificial intelligence began gaining traction in this field. Following initial experimental phases, scholars shifted their focus toward practical efficacy from 2022 onward, marked by studies examining performance metrics and satisfaction levels. As research and implementation deepened, the scope expanded to incorporate emerging keywords, including 5G networks, game-based learning, and content knowledge (as depicted in Figure 9).

In China, since 2020, higher vocational institutions, industry-education integration, and instructional design have constituted major research hotspots in the field of vocational education. By 2021, studies related to information technology, digital skills, and digitization surged dramatically. Subsequently, from 2021 onward, research on digital transformation deepened with focused attention on topics such as digital textbooks, teaching assessment, learning analytics, and professional development. Entering 2024, keywords including “three-track education reform”, “skill substitution”, and “optimization

pathways” experienced rapid growth—signaling an emerging emphasis on systemic approaches within vocational education digitalization. Concurrently, interoperability across educational modalities and implementation frameworks has become central theme (as illustrated in Figure 10).

Figure 9 International research keyword timeline clustering map

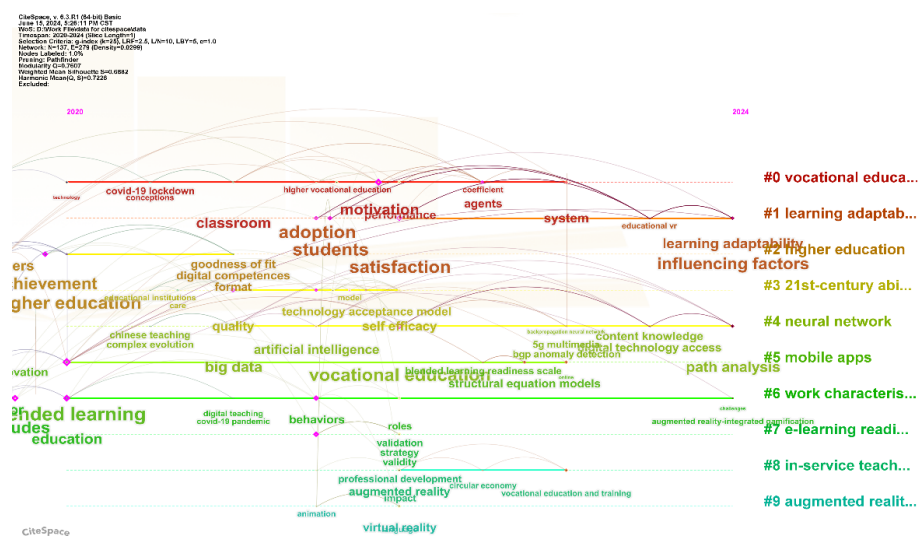
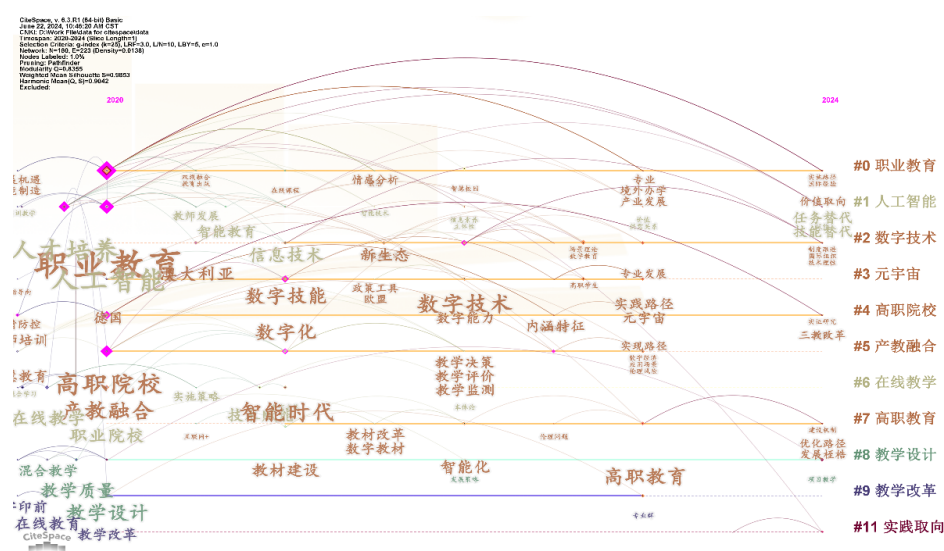


Figure 10 Chinese research keyword timeline clustering map



4. Discussion

4.1 The overall number of documents issued by China is higher than that issued internationally

Annual publication statistics reveal that China consistently produced more papers than the international community in 2020, 2021, 2023, and 2024. Notably, among WOS-indexed publications, China also held the highest output volume. This underscores China's comparatively greater emphasis on research in vocational education digitalization relative to other nations globally. Several factors explain this trend: national strategic planning and policy initiatives have significantly propelled such studies. Within China's broader educational context, its current advancement in educational digitalization represents an extension and innovation built upon prior achievements in educational informatization, long deemed a cornerstone strategy. Key milestones include the Ministry of Education's Action Plan for Education Informatization 2.0 (issued in 2020) and subsequent guidelines on developing high-quality supportive systems through new infrastructure construction (2021). At the 2022 National Education Conference, the Minister explicitly called for implementing a digital strategy in education. Concurrently, revised regulations took effect under China's newly amended Vocational Education Law (2022),

mandating “promoting IT application and integrated use of information resources in vocational education”^[8]. The same year, the Party’s 20th National Congress emphasized coordinating collaborative innovation across vocational, higher, and continuing education sectors^[9], reinforcing vocational education’s strategic importance. Guided by these policies, Chinese researchers intensified their focus on digitalization research, directly contributing to the surge in publications observed during 2023.

4.2 The transformation of higher vocational colleges and digital teaching are the common focus of the world

The statistical results and clustering results of research keywords show that the digital transformation of higher vocational colleges and digital teaching are the focus of global attention. In terms of higher vocational colleges, the keyword “higher education” co-occurred 5 times internationally, ranking ninth in frequency; in China, the keyword “vocational college” co-occurred 23 times, ranking first in frequency. At the same time, the keyword clustering results show that “higher education” and “vocational college” are each a separate category. This indicates that higher vocational colleges are both the focus of research in global digitalization research on vocational education. The reason for this phenomenon may be that the authors of articles mainly come from institutions of higher education, which makes it easier to focus on higher education research.

Regarding digital teaching practices, international clusters included distinct categories such as learning adaptability and e-learning readiness, while Chinese counterparts formed separate groups around instructional design, online teaching, and educational reform. This convergence highlights that technology-mediated instruction remains a central focus globally. Analysis of sampled papers reveals key research trajectories: innovations in pedagogical approaches—including blended online/offline hybrid models^[10] and data-driven precision teaching^[11]; alongside novel assessment methodologies like formative evaluation based on granular teacher-student profiles^[12], and value-added assessment leveraging longitudinal student data^[13]. Both streams demonstrate sustained scholarly attention to classroom dynamics within institutional settings across national contexts.

4.3 China has a first-mover advantage in the research of industry-education integration

The clustering analysis and temporal trends of research keywords reveal that industry-education integration emerges as a distinctive hotspot in China’s scholarship, whereas these dimensions remain underexplored internationally. Notably, the term “industry-education integration” forms an independent cluster exclusively in Chinese publications—contrasted by the absence of industry-related keywords (e.g., enterprises, corporations) in global literature—indicating China’s unique emphasis on leveraging industrial capabilities to advance vocational education development. National strategic prioritization dates back to 2017, when the Report of the 19th CPC National Congress explicitly advocated “deepening industry-education integration”. Concurrently, the State Council issued Guidelines on Promoting Industry-Education Integration^[14]. By 2023, eight ministries jointly launched the Action Plan for Enhancing Vocational Education Through Industry Collaboration (2023–2025)^[15], further solidifying its policy centrality. Practical implementation demonstrates deep synergy between industries and schools in digital domains: iFLYTEK’s intelligent speech evaluation technology now scales across nearly 100 Chinese cities for junior high school English listening assessments^[16]; during the pandemic era, corporate platforms like Tencent Meeting and DingTalk provided critical infrastructure supporting nationwide online education surge—while firms established dedicated edtech ecosystems delivering curriculum resources to teachers and students. Driven by dual forces of top-down policy mandates and grassroots adoption, achieving substantive industry-academia convergence has become a consensus among policymakers and scholars. Given vocational education’s inherent proximity to industrial sectors, such collaboration yields mutual benefits: institutions gain real-time insights into workforce demands, enabling curriculum alignment with job market skillsets and enhancing graduate employability; conversely, industries access tailored talent pipelines meeting their specialized needs. Consequently, industry-education integration constitutes a defining research priority within China’s vocational digitalization agenda.

4.4 Promote digital transformation through supply-side reform of resources

Originally an economic concept, supply-side reform targets equilibrium between demand and supply by enhancing quality, optimizing delivery mechanisms, and refining outcomes^[17]. In recent years, this framework has gained traction in education research, which emphasizes collaborative innovation across three stakeholder groups—governments, institutions, and

enterprises—through institutional restructuring, service model transformation, and platform resource integration^[18]. Within China's vocational education sector, studies predominantly focus on resource provision dynamics. Longitudinal keyword clustering reveals sustained emphasis on digital textbook development over multiple years. Specifically, structural reforms address four dimensions: architecture of resource allocation, tiered resource hierarchies, evaluative metrics for resource efficacy, and modalities of resource distribution^[19]. Practical implementations include: (1) Diversified contributors now encompass academic experts, industry specialists, and frontline educators in content curation^[20]; (2) Expansion from discipline-specific materials to general knowledge repositories^[21]; (3) Evolution of assessment protocols incorporating student feedback alongside expert reviews and third-party validations^[20]; and (4) Leveraging data analytics with knowledge graph technologies to deliver interactive, personalized digital learning resources^[22]. These initiatives collectively advance the modernization of vocational education resource ecosystems through systemic supply-chain optimization.

Looking ahead, advancing the digital transformation of vocational education requires deeper refinement in resource granularity across supply tiers. First, resources should be disaggregated to address contextualized scenarios—currently, comprehensive digital textbooks covering entire courses present limitations due to their scale, multi-stakeholder development processes, extended creation cycles, substantial funding requirements, and predominant focus on generic student needs. To bridge this gap, governments and institutions are encouraged to support educators in developing supplementary micro-lectures or targeted video clips addressing specific knowledge gaps or exercise challenges. Furthermore, beyond course videos, teachers may create auxiliary materials such as guided study handbooks and enrichment activities catering to diverse learner proficiency levels. These complementary resources enable personalized learning pathways while maintaining alignment with core curriculum standards.

5. Conclusion

China's advancement in educational digitalization represents an innovative evolution built upon prior achievements in educational informatization, constituting a comprehensive paradigm shift within the education sector. Amid emerging developmental imperatives, substantial research foundations have already been established in vocational education. To accelerate its digital transformation trajectory, we must leverage accumulated experience to implement demand-driven resource provision and institutional mechanism innovation—ensuring educational resources achieve enhanced efficiency and precision in serving educators and learners. Moreover, capitalizing on China's first-mover advantage in vocational education digitalization calls for proactive dissemination of research outcomes while strengthening international collaboration. This strategic approach will elevate China's global standing and influence in the field. Through sustained commitment to innovation, we can contribute Chinese insights and solutions to advance worldwide vocational education development, jointly propelling progress in global educational endeavors.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Data-Driven Practical Approaches to Integrating Teaching, Learning, and Assessment in English

Zekai Guo, Yan Kou, Yuhan Xu, Hailin Zhang, Meng Cui*

School of Teacher Education, Guangdong University of Education, Guangzhou, 510303, China

*Corresponding author: Meng Cui, mengcui@m.scnu.edu.cn

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Abstract: With the in-depth development of big data technology in the field of education, data-driven integration of teaching, learning, and assessment has become a mainstream pedagogical paradigm. The Compulsory Education English Curriculum Standards (2022 Edition) explicitly proposes the integrated design concept of "teaching–learning–assessment," emphasizing that assessment should permeate the entire teaching process to promote the cultivation of core competencies. However, current junior high school English teaching still faces issues such as disconnection between teaching objectives and assessment, reliance on experiential judgment in learning analytics, lagging assessment feedback, and imbalance between technological application and educational value. Based on this, this study utilizes the Ekwing intelligent platform as a technical support to construct a data-driven integrated "teaching–learning–assessment" learning model. Through three major strategies—anchoring teaching objectives guided by curriculum standards, reconstructing the teaching ecology empowered by the intelligent platform, and establishing a cyclical data-driven teaching–learning–assessment system—the study breaks down the barriers between theory and practice. It constructs a practical pathway for data-driven integrated teaching–learning–assessment to empower the cultivation of core competencies and the enhancement of English learning ability, aiming to provide practical references for promoting the digital transformation of English teaching and the efficient transformation of traditional classrooms.

Keywords: Integration of Teaching; Learning; and Assessment; Data-Driven; Junior High School English; Core Competencies

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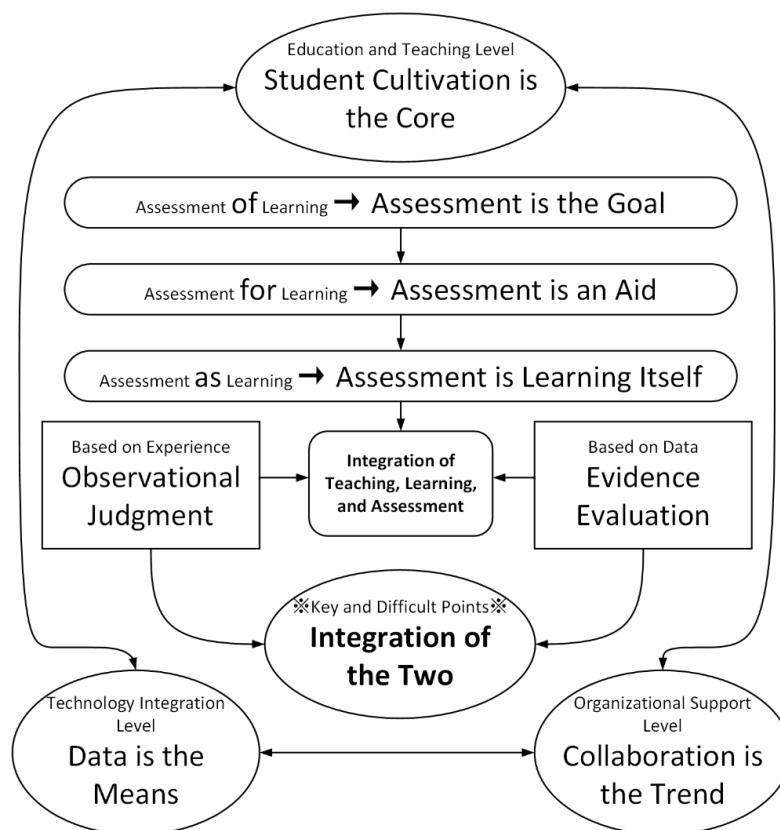
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1.Introduction

Cultivating students' disciplinary core competencies is the central goal of deepening curriculum reform. As teaching, learning, and assessment share the common essence of developing students' disciplinary core competencies^[1], promoting the integrated design of teaching, learning, and assessment is a key pathway to achieving this goal. The Compulsory Education Curriculum Standards (2022 Edition) explicitly states the need to "strengthen the alignment among assessment, curriculum standards, and teaching, promote the organic connection of 'teaching–learning–assessment,' and emphasize conducting assessment alongside the teaching process." The integration of "teaching–learning–assessment" is a synergistic process involving simultaneous learning, teaching, and assessment. Specifically, it refers to the process where teachers and students integrate assessment into the entirety of teaching and learning through visible learning evidence while completing assessment tasks. They infer the effectiveness of teaching and learning based on assessment evidence, engage in continuous reflection to improve learning

plans, and present these plans in an understandable manner. The new curriculum standards' emphasis on students' self-evaluation and self-reflection abilities, and on guiding students to reasonably use assessment results to improve learning, signifies a shift in educational assessment from "assessment of learning" to "assessment for learning" and "assessment as learning." This marks a profound transformation in educational assessment philosophy—from focusing on "assessment of learning" to placing greater emphasis on "assessment for learning" and "assessment as learning"—highlighting the core concept that "assessment promotes learning"^[2]. The effective integration of assessment and its resonance with teaching practice have become the cornerstone for realizing disciplinary education.

Figure 1 The Integration of Teaching-Learning-Assessment



However, in the traditional educational assessment system, learner evaluation often combines formative and summative assessments, suffering from issues such as singular assessment content and methods. With the increasing richness of collectible learner process data, traditional educational assessment is transitioning towards big data-driven scientific evaluation. The deep integration of big data—encompassing data theory, tool theory, and methodology—with teaching has reshaped the "teaching" and "learning" activities of teachers and students, prompting a shift in the teaching paradigm from "experience-based" to "data-driven": teaching content advances from "disciplinary knowledge" to "individual wisdom"; teaching methods move from "standardized instruction" to "embodied experience"; and teaching evaluation transitions from "observational judgment" to "evidence-based evaluation"^[3]. The essence of the consistency among teaching, learning, and assessment lies in breaking through the traditional isolation and separation of teaching and assessment, ensuring that assessment is no longer superimposed upon or detached from teaching but is embedded within it, becoming an organic component of teaching. The operational mechanism of "data-driven" teaching involves multilateral interactions among teachers, students, teaching media, and content centered around teaching big data^[4]. The Compulsory Education English Curriculum Standards (2022 Edition) also encourages teachers to innovatively use digital technologies and online platforms to support personalized learning needs. Thus, advancing the integrated design of teaching, learning, and assessment in depth is inseparable from the empowerment of modern information technology.

In this context, English intelligent education platforms represented by "Ekwing," with their accompanying assessment mechanisms that collect, analyze data, and generate feedback in real-time, have become typical examples of data-driven

integration of teaching, learning, and assessment, facilitating the implementation of core competencies. Consequently, refining the practical pathway for "data-driven integration of teaching, learning, and assessment" based on intelligent platforms and big data is not only an inevitable requirement to respond to the core demands of curriculum reform and the transformation of assessment concepts but also a key measure for enhancing the effectiveness of English teaching and implementing the new curriculum standards.

2. Current Situation and Problems

2.1 Disconnection Between Teaching Objectives and Assessment Criteria

A prevalent issue in current junior high school English classrooms is the two-dimensional separation between "objectives" and "assessment." In teaching practice, most teachers have not yet deeply understood the educational function of assessment. Their goals for cultivating students' abilities remain unclear, and instruction is still largely oriented towards knowledge transmission—for instance, emphasizing grammatical knowledge while neglecting language proficiency^[5]. Classroom assessment lacks an intrinsic connection with educational goals, and there is a failure to establish assessment criteria based on teaching objectives. This leads to a frequent disconnect between teaching, student learning, and student assessment. Student assessment is often treated as an isolated segment rather than being effectively integrated into the teaching process.

2.2 Experience-Based Dependency in Learning Analytics

In traditional classroom teaching, teachers' judgments of student learning status mostly rely on fragmented information such as classroom observation, question-and-answer sessions, and homework correction. This improvisational assessment, based on personal experience, is highly subjective and inefficient. It often merely judges the correctness of learning outcomes without accurately identifying individual student differences, pinpointing learning problems, or enabling timely adjustments to teaching strategies. Consequently, it lacks effective guidance for student learning itself, making it difficult to achieve truly personalized learning support, which in turn hampers the improvement of teaching effectiveness^[6].

2.3 Lagging and Monotonous Assessment Feedback

Most teachers often compress assessment into a "summary segment" at the end of the class to complete pre-set teaching steps smoothly, lacking awareness of "teaching–learning–assessment" as an integrated whole^[7]. There is an over-reliance on summative assessment and a neglect of process data in evaluation. This results in students passively receiving assessment results without developing the initiative for self-adjustment. This phenomenon prevents teaching effectiveness from reaching its optimal state, fails to fully stimulate students' learning motivation and creativity, and makes it challenging for teachers to establish effective interaction and feedback mechanisms in practice. It hinders teachers from adjusting teaching strategies promptly based on student learning status and assessment feedback, and likewise impedes students from using feedback to adjust their learning strategies in a timely manner, ultimately leading to a situation of "teaching without assessing" or "assessing without improving."

2.4 Imbalance Between Technological Application and Educational Value

The application of digital technology in English classrooms often remains at a superficial level, such as displaying slides or using question bank drills. Although some teachers introduce intelligent platforms into their lessons, they are used merely for assigning homework or listening exercises. These standardized online resources are difficult to adapt to students' diverse cognitive styles and varying paces of competency development. They fail to meet personalized learning needs and do not fully leverage the potential for real-time, data-driven regulation of the English classroom. As a result, the effectiveness of English teaching cannot be optimized, students' learning enthusiasm and creativity are not fully engaged, and teachers struggle to form effective interactive and feedback mechanisms in their teaching practice.

3. Value Demonstration of Data-Driven Integration of "Teaching-Learning-Assessment"

3.1 Enriching the Teaching Evaluation Paradigm and Achieving Diverse Evaluation Standards

A teaching model is a relatively stable structural framework and activity procedure for teaching activities established under the guidance of specific teaching theories or philosophies. Currently, China's education field exhibits diverse educational models, including self-study-tutoring models, inquiry-based teaching models, exemplary teaching models, and Butler's

"Seven Segments" teaching model, among others^[8]. Junior high school students are in a special developmental period of adolescence, with relatively high brain plasticity, strong self-awareness, and cognitive learning abilities. Traditional teaching models lack diverse evaluation paradigms and rely solely on post-lesson test scores as evaluation criteria, which severely stifles students' individual development and hinders the goal of "holistic education." Leveraging its smart classroom functions, the Ekwing platform collects students' learning data in real-time. By analyzing metrics such as student engagement rate (e.g., "heads-up" rate), micro-expression analysis, and speech emotion analysis, it enriches the forms of summative assessment and promotes the transformation of summative evaluation from a single written score standard to multidimensional evaluation criteria. Simultaneously, teachers can assign pre-class preview tasks to achieve precise learning analytics for students and obtain diagnostic assessment data.

3.2 Countering Personal Empiricism and Boosting Teacher Team Development

In teaching activities, teachers, as the "gatekeepers" of the teaching process, play a decisive role in controlling teaching information^[9]. However, influenced by variations in teaching ability levels, teachers often tend to rely on personal experience to make subjective judgments about students' learning behaviors, resulting in assessment feedback that is not timely or effective enough^[10]. Through functions like synchronized training, extended practice, and listening/speaking tests, the Ekwing platform provides teachers with comprehensive, chain-linked learning data for each student, effectively mitigating the negative impact of teachers' individual subjective inclinations. Furthermore, teachers can use the Ekwing platform to incorporate digital resources for vocabulary, grammar, listening, and speaking into their lesson preparation, thereby enhancing their classroom teaching quality. Teachers are no longer merely "knowledge transmitters" but become "strategic designers" of the classroom. The introduction of intelligent educational platforms can significantly enhance teachers' technological application skills and digital leadership, cultivate the digital literacy of China's teaching workforce, and lay a solid foundation for building China into a strong power in digital education^[11].

3.3 Creating Multi-Dimensional Student Profiles and Improving Classroom Teaching Quality

In traditional English listening and speaking teaching, teachers find it difficult both to assess the developmental level of the entire class before the lesson and to accurately gauge students' dynamic learning status during the lesson^[12]. By introducing the Ekwing intelligent platform, teachers can uniformly organize students to conduct English listening and speaking training, collect activity data from students' daily practice, perform learning analytics based on data from different students, and create multi-dimensional student profiles. To address pain points such as students' reluctance to speak or poor foundational speaking skills, targeted listening and speaking exercises can be assigned for training, effectively solving problems like students' fear of speaking or inability to speak. For students with relatively better speaking foundations, advanced exercises are provided to help them correct pronunciation and take their oral proficiency to the next level. Meanwhile, Ekwing uses textbooks as its core benchmark, providing different teaching materials for different grades, effectively meeting actual teaching needs and enhancing classroom teaching quality.

4. Implementation Strategies for Data-Driven Integration of "Teaching-Learning-Assessment"

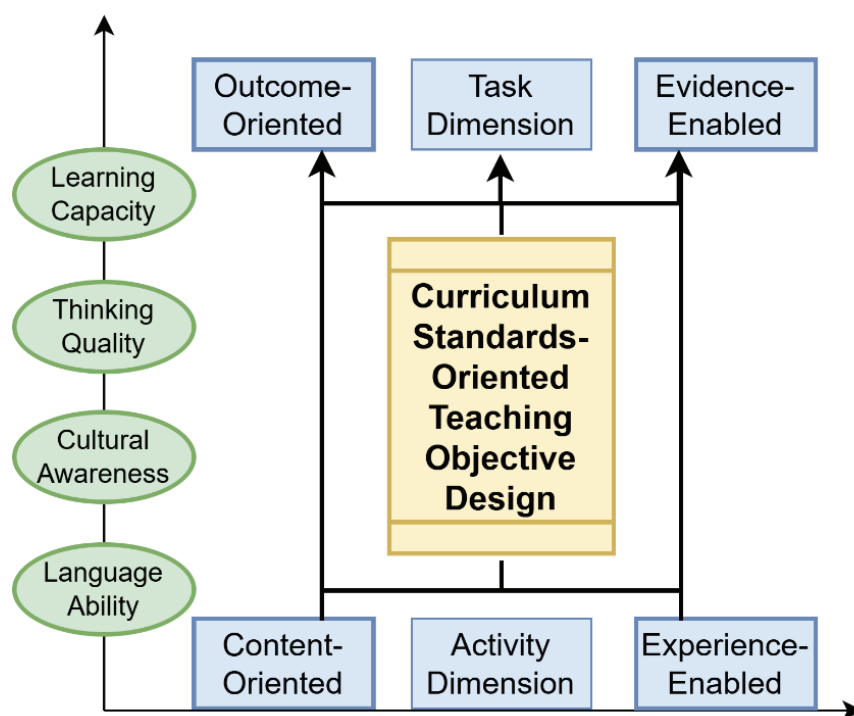
4.1 Curriculum Standards-Oriented Setting of Teaching Objectives

As the core element of integrating teaching, learning, and assessment, teaching objectives possess a three-dimensional guiding function in instruction: guiding learning, guiding teaching, and guiding evaluation. Teaching objectives serve as the action guide for student learning, the implementation blueprint for teacher instruction, and the benchmark for evaluating teaching effectiveness. They are the starting point and ultimate goal of teaching, the soul of instruction, governing the entire teaching process. This implies that when preparing lessons, teachers must first clarify the teaching objectives for that lesson, treating them as the "root" and "source" of effective classroom instruction (i.e., the foundational basis of teaching). If teachers do not deeply contemplate and formulate teaching objectives, instruction becomes like water without a source, losing its direction, and the integration of "teaching-learning-assessment" becomes impossible.

Based on this, teachers must anchor their instructional design in the curriculum standards, use the core competencies of the English subject as the framework, and employ backward design thinking to construct a three-dimensional teaching

objective system^[13]. Specifically, a "begin with the end in mind" backward instructional design approach should be adopted, coordinating the vertical transformation of three-level objectives with the horizontal shift in three-dimensional design: ① On the vertical dimension: Based on the four dimensions of English core competencies—"language ability," "cultural awareness," "thinking quality," and "learning capacity"—and after studying and deconstructing the curriculum standards, systematically plan the academic year teaching objectives. These are then broken down into unit teaching objectives and finally refined into concrete, operable lesson teaching objectives, clearly defining what students need to achieve in each lesson. ② On the horizontal dimension, simultaneously promote a three-dimensional design shift: Learning objective design shifts from "content-oriented" to "result-oriented"; Teaching process design shifts from "activity-focused" to "task-focused"; Learning assessment design shifts from "experience-enabled" to "evidence-enabled"^[14]. This hierarchical, multi-dimensional objective-setting strategy ensures both the value alignment of micro-level teaching practices with macro-level educational goals and provides clear implementation signposts for each stage of teaching, learning, and assessment.

Figure 2 Design of Teaching Objectives



4.2 Teaching Ecology Transformation Driven by Intelligent Educational Platforms

As the core vehicle of the digital transformation in education, intelligent platforms not only provide multimodal means, platforms, and spaces for English teaching but also offer abundant resources and cross-spatiotemporal opportunities for language learning and use. They play a vital supporting role in creating favorable learning contexts, promoting the renewal of educational concepts, and transforming teaching methods^[15]. In the practice of constructing an integrated "teaching-learning-assessment" system, intelligent platforms serve as important tools, demonstrating significant technology-enabled effects in reconstructing the relationships between teaching subjects and reshaping learning practice paradigms.

4.2.1 Reconstructing Teaching Subject Relationships and Realizing Role Evolution

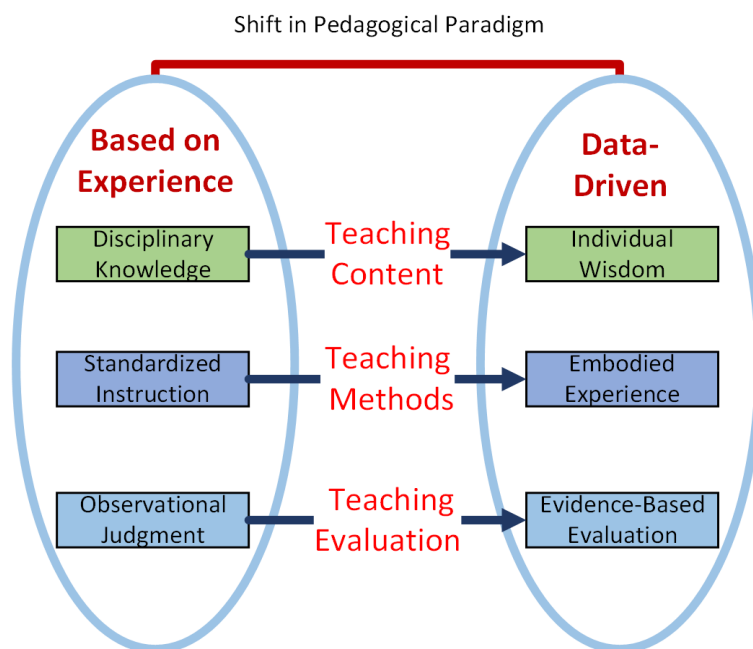
Intelligent platforms represented by "Ekwing" can reshape the production relationships in English education through data interconnection and intelligent analysis technologies. In the English classroom, teachers can leverage the intelligent platform to redefine their roles: by precisely adjusting teaching plans based on the dynamic learning status data from the Ekwing platform, they transition from "knowledge transmitters" to "strategic designers." Students can rely on the platform's personalized learning paths to regain sovereignty over their learning, evolving from "objects of assessment" to "sovereign learners." Assessment can break through the limitations of traditional measurement tools; through instant feedback mechanisms that continuously optimize learning efficacy, it evolves from a "standardized measurement tool" into a "meta-tool

promoting cognitive development" ^[16].

4.2.2 Reshaping Teaching Practice Paradigms and Promoting Goal Transformation

The classroom is the primary venue for implementing the integration of teaching, learning, and assessment. Intelligent platforms drive the transformation towards this integration in classroom teaching through two main pathways: ① Competency-Oriented Unit Objective System: Using the curriculum standards as an anchor, Ekwing can intelligently match textbook content, unit themes, instructional design, and assessment tasks, ensuring the coherent implementation of unit objectives and competency goals within the classroom. ② Data-Driven Assessment Evidence Loop: Functions such as platform-wide collection of behavioral data throughout the learning process and multimodal performance assessment provide a chain of process data evidence for teaching monitoring. This builds a cyclical optimization mechanism of "objective - implementation - analysis - iteration," forms an evidence chain supporting the dynamic adjustment of teaching strategies, and achieves a closed loop ensuring the consistency of teaching, learning, and assessment ^[17]. During lessons, teachers can use the intelligent Ekwing platform to create informatized teaching scenarios and authentic English language application contexts. This promotes the transformation of the English classroom from "textbook knowledge indoctrination" to "core competency cultivation," accomplishes the systematic reconstruction of teaching objectives, processes, and assessment, and ultimately achieves alignment among curriculum standards, textbooks, teaching, and assessment within the English classroom.

Figure 3 Shift in Pedagogical Paradigm



4.3 Reform of the Teaching-Learning-Assessment System Empowered by Educational Data

The consistency of "teaching-learning-assessment" requires that teaching evaluation aligns with teaching objectives. Evaluation activities consist of teaching and learning objectives, along with matching evaluation criteria and tasks, aiming to monitor the effectiveness of teaching and learning ^[18]. Evaluation is not subjective conjecture, nor should it be confined solely to determining whether learning objectives have been met. Instead, it should involve scientific, objective, and fair judgments of student learning evidence based on certain standards. Qualified evaluation should be continuous throughout the teaching and learning processes, serving as an integral part of classroom activities, not just implemented after teaching and learning conclude. Scientific evaluation relies on learning evidence, which originates from students' authentic learning processes and requires collection through various methods and tools ^[19].

The key to evaluation lies in obtaining relevant information from the student learning process and then using this information to support subsequent teaching and learning decisions, thereby helping students achieve the preset teaching objectives. Data-driven teaching-learning-assessment does not seek to replace the measurement of teaching effectiveness with data, but rather uses data as an auxiliary tool for teaching verification, serving the diagnostic and improvement functions of evaluation ^[20].

It is crucial to recognize that the inherent complexity of education makes intuitive data difficult to interpret simplistically. Therefore, we must avoid exaggerating the educational interpretability of data and guard against the cognitive bias of "data supremacy"—we must neither overinterpret the educational explanatory power of data nor allow data to become a rigid evaluation metric. Data should merely provide teachers and students with immediate evaluation evidence to improve teaching and enhance learning. The integration of information technology and data should not diminish teachers' instructional agency. Instead, it should emphasize the deep fusion of professional wisdom and technological tools: teachers must maintain a keen insight into the classroom context, making observational judgments based on experience, while also skillfully using data tools for evidence-based assessment and evaluating teaching effectiveness based on data. They need to preserve experience-guided teaching judgments while developing data literacy to support precise diagnosis. This organic integration of technology and education preserves the humanistic warmth of teaching while enhancing the scientific validity of assessment, ultimately contributing to a healthy developmental ecosystem for the integration of teaching, learning, and assessment.

Conclusion

The value orientation of integrating "teaching–learning–assessment" will induce numerous changes in the relationships among instructional design elements and promote positive effect sizes in classroom teaching. With the rapid advancement and exploration of big data technology in the educational field, data-driven integration of teaching, learning, and assessment is gradually becoming a mainstream pedagogical paradigm in the big data era. When clarifying the approach to this integration, it should be understood that at the educational level, cultivating student is the core, while at the technological integration level, data is the means. The implementation framework for the trinity of "teaching–learning–assessment" must be established based on curriculum standards. Relying on intelligent platforms, an integrated design philosophy of "merging learning with assessment and using assessment to inform teaching" should be adopted. Adhering to the combination of formative and summative assessments, a competency-oriented English curriculum education system featuring diverse participants and multiple methods should be gradually established. This aims to achieve the integration of teaching objectives and learning goals, teaching processes and learning activities, and assessment feedback and learning reflection. Ensuring the effective implementation of "teaching–learning–assessment" consistency in the classroom will realize the goals of using assessment to promote learning, using assessment to improve teaching, and fostering mutual enhancement between teaching and learning.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Effect of Smart Classroom Learning Modes and Strategies on Student's Academic Capability at Primary Education

Jinjin Bian, Qiudi Wu, Huayang Zhang*

School of Digital Media, Shenzhen Polytechnic University, Shenzhen, Guangdong, 518055, China

*Corresponding author: Huayang Zhang

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Abstract: The rapid advancement of technology promotes the development of modern education technology while catalyzing transformation and innovation in teaching. A smart classroom with effective learning modes and strategies enables students' academic growth, whereas the physical environment of a smart classroom alone can only have limited effect on students' academic growth. Conducting research on smart classroom learning modes and strategies holds both theoretical significance and practical value for promoting students' academic achievement. The objective of this study is to determine the effect of smart classrooms learning modes and strategies among primary school students. The study involved 36 students, and the data were analyzed using test. The results show a significant difference in the students' academic performance between the conventional learning modes and strategies and smart classroom learning modes and strategies. In addition, the use of smart classroom learning modes and strategies has greatly improved students' performance in several areas: personalized learning capacity, autonomous inquiry, knowledge construction, collaborative interaction, innovative utilization of information resources, and self-assessment capabilities.

Keywords: Informationization; Smart Classroom; Learning Modes; Learning Strategies

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1.Introduction

In the current era, characterized by unprecedented technological progress, a wave of innovation and transformation in education has been ignited by the emergence of next-generation technologies including artificial intelligence and AR/VR technology, among other cutting-edge information technologies, have spurred significant transformations and innovations in education (Kwet & Prinsloo, 2020). This evolution has given rise to the concept of "smart education," but it is not just about embracing technology. Smart classrooms, which are pivotal components of smart education, designed to elevate the experience for teachers and students. These smart classrooms define a new learning paradigm marked by distinct attributes: shared premium resources, real-time assessment and feedback mechanisms, diverse modes of communication and interaction, intelligent resource delivery, individualized learning experiences, tailored teaching approaches, and data-driven management strategies. As such, the exploration of learning modes and strategies tailored for smart classrooms holds profound theoretical significance and practical worth. It plays a crucial role in nurturing students' intellectual maturation, driving the personalization and holistic growth of education, accelerating the advancement of educational informatization, and ultimately, elevating the overall quality of education.

1.1 Current research regarding learning modes and strategies

Despite the widespread acceptance of the philosophy behind smart education, practical implementation methods, particularly the specific construction measures and implementation techniques for smart classrooms, still present challenges (Saini & Goel, 2019). Currently, the design of teaching modes in smart classrooms and the exploration of corresponding teaching strategies are at an early stage, lacking detailed, concrete, and proven-effective implementation plans (Lu et al., 2021). The current learning modes still have deficiencies in the design of their constituent elements, and their feasibility and effectiveness have not been comprehensively validated. Therefore, conducting in-depth research into learning modes and strategies tailored for smart classrooms not only bridges the gap between theory and practice but also provides strong support for enhancing teaching quality and achieving educational equity. Thus, further promoting the healthy development of the smart education endeavor.

This paper identifies that research on learning modes and strategies within smart classrooms largely relies on project-based practice, typically focusing on aspects such as instructional design and implementation. It tends to delve into these areas while also addressing current research hotspots, paying considerable attention to the establishment of a technological environment and the development of learning resources.

2. Literature review

2.1 Smart Classroom

Smart classroom refers to the use of technologies and services such as cameras, interactive boards, smart attendance systems, and a student response system in the learning process, which not only can provide students with better access to what they need, but also allow educators to evaluate their students' response in real time (Mircea et al., 2021). In the current context of building smart classrooms, significant challenges lie predominantly in the realization of personalized learning, adaptive learning, and learning analytics.

Firstly, personalized learning caters to students' diverse learning needs. Educators are tasked with providing a broader array of choices and distinct learning approaches for students to accomplish personalized learning. In the era of big data, it is the responsibility of educational departments and institutions to explore how information technology can be leveraged to help students tackle complex problems and cultivate systemic thinking based on the cognitive level, preferences, and learning style of the students, among other factors (Zhang, 2022). Secondly, adaptive learning enables tools to automatically align with students' learning requirements. Adaptive learning technologies refer to software and online platforms that proactively respond to students' learning needs (Alam, 2022). This advanced, data-driven form of learning tracks students' academic progress, reflecting their engagement levels and performance metrics. Thirdly, learning analytics plays a crucial role in the design process of smart classrooms by collecting and analyzing data accumulated in a smart classroom (Aguilar et al., 2018). Beyond merely measuring student progression, learning analytics also adapt and respond to the teaching and learning requirements of students. Within curriculum instruction, learning analytics technologies combine data analysis and visualization techniques, in order to improve the learning process (Aguilar et al., 2018). However, early studies mainly focused on the effectiveness of smart classroom facilities and information gadgets rather than the specific learning modes and strategies that can contribute to the effective use of such classroom.

2.2 Smart Classroom Learning Mode

Research related to smart classroom learning modes includes those involving mobile technology-supported smart classroom learning, activity-centered smart classroom learning, as well as personalized, autonomous, and collaborative inquiry-based learning modes.

Firstly, concerning the smart classroom learning mode focused on mobile information technology, Liu (2021) proposed it is necessary to construct English smart classroom and innovate teaching mode under the background of Internet of Things (IoT) multimedia communication. Hu (2023) argued that in the field of wisdom, applying IoT technology to classrooms can effectively improve the deficiencies of traditional teaching models, Albalawi's (2013) research suggested that tangible interaction interfaces based on mobile intelligent terminals could facilitate student's development of learning abilities

and social interaction skills through interactive learning experiences. Finally, focusing on personalized, autonomous, and collaborative inquiry-based learning modes, Slotta et al. (2008) introduced the Knowledge Community and Inquiry (KCI) instructional model that integrates a dimension of scaffolded inquiry within a knowledge community approach. This model promotes collaborative exploration among students. Benkiran et al. (2015) posited that in a smart classroom setting, students can follow their own pace to learn or selectively access knowledge relevant to them to participate in courses effectively.

2.3 Smart Classroom Learning Strategy

Research related to smart classroom learning strategies includes the study of strategies that examine how and to what extent smart classrooms transform the dynamic of teaching and learning of students thereby improve learning experiences. In addition, project-based research focuses on smart classroom learning strategies for the purpose of understanding and optimizing the learning process and the teaching environments.

Firstly, concerning studies on how learning strategies in smart classrooms improve student learning capabilities, Christensen (2008) posits that a smart classroom constitutes a student-centric and intelligent environment that integrates multiple technological means such as smart devices, interactive whiteboards, and wireless network technologies in a way that humanizes education and promotes personalized and diversified pathways to improve students' academic outcomes. Secondly, attention is given to project-based research underpinning the development of information-focused smart classroom learning strategies. For more than two decades, the Maine Learning Technology Initiative (MLTI) investigated the effectiveness of various kinds of learning strategies in smart classrooms, for instance, the use of portable computers for every 7th and 8th grade students and middle-level educators (Maine Government, 2023). Moreover, Canadian universities have also conducted research by analyzing typical behaviors of 1,129 students using intelligent devices in their classes to examine whether these devices genuinely enhance students' learning abilities.

3.Design of Learning Models and Strategies for Smart Classrooms

3.1 Design of the Learning Model for Smart Classrooms

By integrating domestic and international research findings on the design aspects of learning scenarios, learning resource design, learning activity design, learning process design, and learning environment design in the context of smart classrooms, a learning mode for a smart classroom is formulated, guided by theories such as Smart Learning Theory, Learning Activity Theory, and Situated Cognition Theory.

3.1.1 Inspirations from Smart Learning Theory for Personalized Learning Design

Smart learning necessitates the recognition and understanding of fundamental facts and objective laws governing phenomena, as well as the application of knowledge and skills to create artifacts that meet personal, societal, and communal needs. It fosters mutual influence, reciprocal shaping, and bidirectional adaptation between students and their environment. In a smart learning environment, students should proactively engage in their studies, collaborate and support one another, and have the opportunity to learn anytime, anywhere, and according to their individual needs (Zhu & He, 2012).

Smart learning integrates intelligent information technology with learning activities, enabling students to access resource information and facilitating effective interaction among students themselves or between students and teachers. Moreover, it designs self-directed learning environments for students (Lee et al., 2012). Thus, in constructing the learning model for a smart classroom, it is essential to fully leverage its characteristics of personalized and collaborative environments, intelligent tracking, and a rich array of tools. This involves making appropriate choices in pedagogical approaches, subject content, and supportive technologies to facilitate the occurrence of wisdom-based learning among students.

3.1.2 Insights from Learning Activity Theory for the Design of Learning Activities

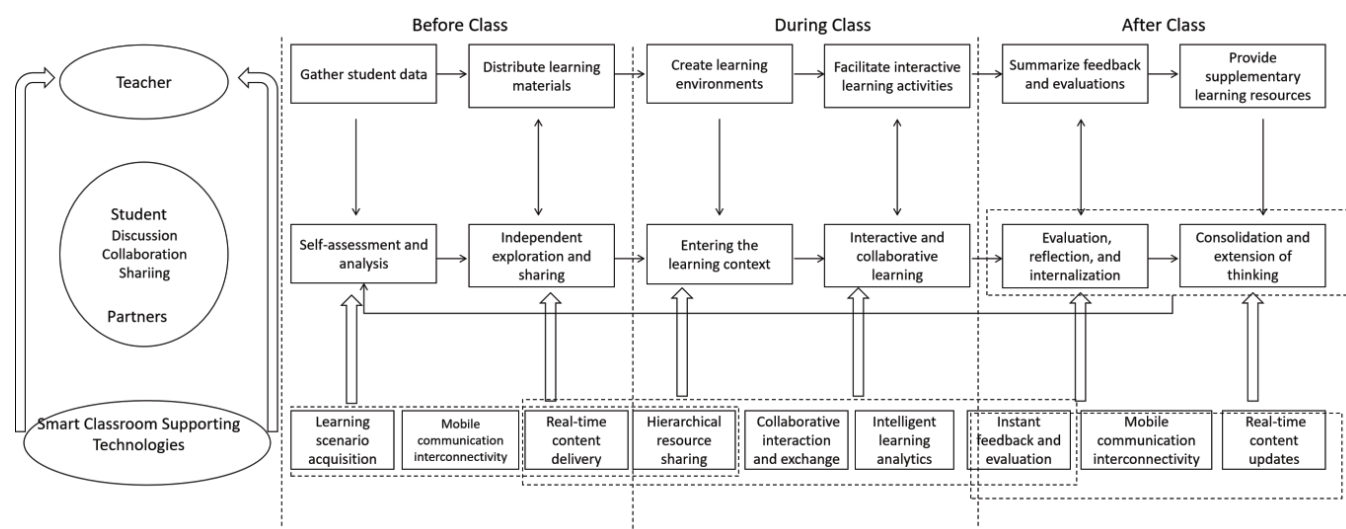
Drawing from the relevant findings in Activity Theory, learning can be viewed as a holistic learning activity system. In this system, the subjects correspond to different roles, with the objects referring to the teaching content designed according to curriculum objectives. The division of labor, in the context of learning, pertains to the allocation of learning tasks among students (Yang, 2010). In the context of a smart classroom learning activity that is geared towards informatization, learning rules encompass teaching regulations, interaction norms among students, and evaluation criteria for learning outcomes. Here,

the subject refers to the broad concept of students, which includes all participants in the learning process. The object denotes the subject matter being studied. The community constitutes the collective of learning partners and teachers who collaborate with students in accomplishing the learning process. Tools represent the intelligent supportive technologies employed during the learning process. Rules are the agreements that facilitate the coordination between subjects and objects within the smart classroom's learning activities. Learning division of labor pertains to the allocation of different learning tasks among various participants involved in the learning activities within such a smart classroom setting.

3.1.3 Insights from Situated Cognition Theory for Learning Context Design

In a smart classroom, it is essential to provide students with concrete learning contexts that facilitate the construction of their knowledge. These learning contexts support the development and application of conceptual understanding and methods in domain-specific knowledge. Students can leverage these contexts to build their cognitive frameworks, thereby aiding in the internalization of knowledge.

Fig. 1. Diagram of the Learning Model for Smart Classrooms



3.2 Design of Learning Strategies for Smart Classrooms

In this paper, drawing upon research on learning strategies by scholars (Weinstein, 1990; Pokay, 1990; Mckeachie et al., 1990), an analysis is conducted on the effective learning procedures, methods, techniques, and regulatory approaches that need to be considered in the learning process within smart classrooms. Combining empirical experiences gathered from case studies in smart classroom environments, this section discusses the learning strategies for such classrooms from three dimensions: cognitive strategies, resource management strategies, and multifaceted assessment strategies.

3.2.1 Cognitive Strategies

Preparation: Prior to lessons in a smart classroom, teachers can use intelligent terminals to engage students with questions and discussions, identifying their learning styles, weaknesses, and attitudes toward upcoming content. By pinpointing entry points, they can effectively organize teaching materials, setting clear objectives, content, challenges, and even sharing lesson designs. Students utilize terminals to familiarize themselves with resources and apps beforehand. For instance, in a primary school English class, pupils might learn animal vocabulary via tablets and upload collected images and audio recordings for group sharing.

Interactive Engagement: The smart classroom facilitates dynamic learning through diverse interactive spaces. Teachers create virtual scenarios where students interact and manage their time effectively. Leveraging software tools, instructors can prompt inquiry-based or task-driven activities that stimulate critical thinking and deepen understanding, e.g., composing music on a tablet app then playing it on a recorder.

3.2.2 Resource Management Strategies

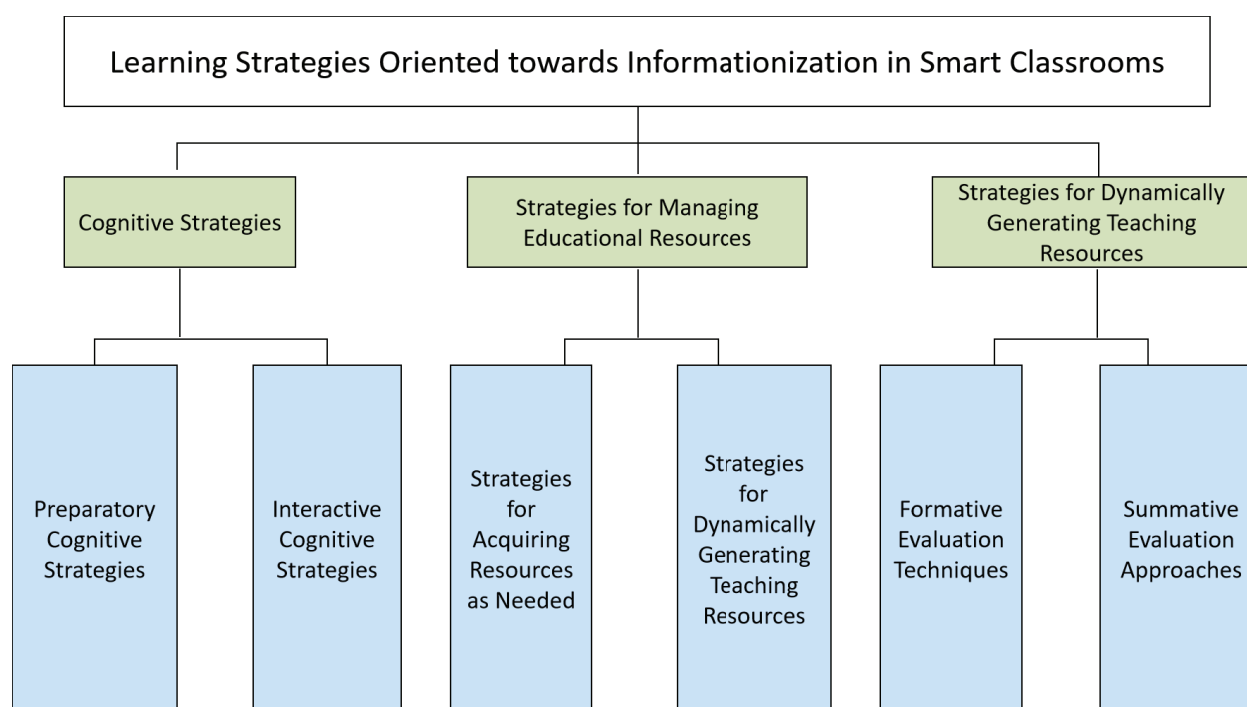
Acquisition of Resources: Smart classrooms involve a variety of hardware (e.g., tablets, interactive whiteboards, servers, network devices) and software resources (cloud libraries, teacher-shared materials, real-time pushes, and student-contributed

content). Students access resources adaptively based on collaborative filtering, content sequencing, and related knowledge, enhancing problem-solving skills.

3.2.3 Multifaceted Assessment Strategies

Interactive technologies transform resource creation and presentation. Teachers develop tailored, interactive resources while the system records and analyzes students' learning behaviors, creating valuable data for future reference. Students are encouraged to actively generate and share self-created resources, contributing to the educational database. This not only expands native resource generation but also organizes them hierarchically, making them easily accessible and memorable. In practical examples, students may collaborate to produce instructional videos which they upload and share within the smart classroom ecosystem, broadening their knowledge horizons and fostering creativity.

Fig. 2. Diagram of Learning Strategies for Smart Classrooms



4. Method

4.1 Participants

The test subjects consisted of 36 primary school students from Grade 4 Class (4) at Guangzhou Yunshan Primary School who were studying the subject of Mathematics. The experiment employed the smart classroom learning model and strategies as independent variables, with the learning outcomes serving as the dependent variable.

4.2 Procedures

The experiment utilized a pre-test and post-test within a single group, as well as questionnaire surveys, to validate the effectiveness of applying the smart classroom learning model and strategies.

In the pre-test phase, the teacher presented the 'Vertical and Parallel Lines' lesson content in the smart classroom environment without employing the targeted learning model and strategies. The process included the following steps:

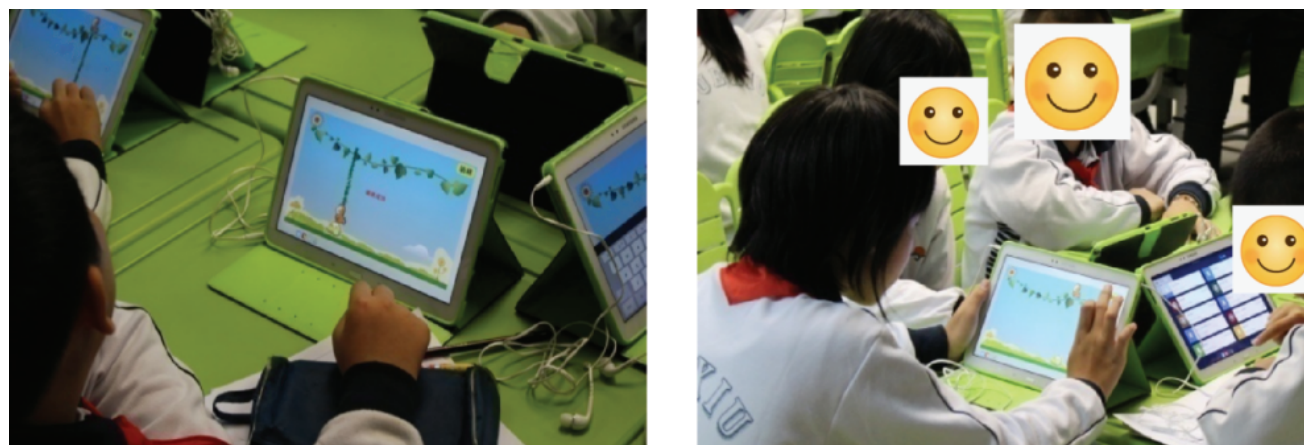
Learning session on the topic "Vertical and Parallel Lines;"

Quality assessment of learning, where the researchers collaborated with the class teacher to design an in-class test consisting of 2 major questions encompassing a total of 15 sub-questions;

A survey on students' attitudes toward their personalized learning process.

After this initial teaching period, the targeted learning model and strategies were implemented for the subsequent lessons, followed by a post-test to compare the results before and after the application of these strategies.

Fig. 3. Students Engaging in Math Games



The post-assessment content is facilitated by the same mathematics teacher within a smart classroom learning system environment that embraces information teaching models and strategies, giving a lecture to students about “drawing perpendicular lines.” The process unfolds as follows:

Learning Community Design: Prior to the class, teachers, students, and peers collaboratively establish learning objectives, aiming to master the skill of accurately drawing perpendicular lines.

Learning Activity Design integrated with information-enabled smart classroom learning approaches:

- (1) **Preview:** Students engage in analysis of drawing perpendicular lines, sharing videos for discussion.
- (2) **Game-based Introduction:** A game is used to create a contextualized learning scenario.
- (3) **Review and Presentation of Pre-class Preparation:** Homework assignments are critiqued, and learning roadmaps are presented.
- (4) **Mastery of Drawing Perpendicular Lines through Given Points:** Two tasks are completed. Task one involves teachers sharing resources; students view these while completing outlines and uploading photos of their work. Task two requires group discussions where teams draw corresponding perpendicular lines according to the outline, record videos of the process, and submit them.
- (5) **Group Presentations and Real-time Peer Reviews:** Teams present their findings, engaging in peer evaluation activities.
- (6) **Completion of Advanced Exercises and Surveys:** Students tackle progressive practice exercises and surveys, with real-time display of answer progress, immediate feedback on scores, and dissemination of survey results, culminating in summary evaluations.
- (7) **Student Self-reflection Using PMIQ (Gains, Improvements Needed, Questions, and Puzzles):** Students reflect on their learning experience.
- (8) **Completion of Post-class Assignments:** students wrap up with after-class homework tasks.

Fig. 4. Creation of a Mathematical Game Practice Scenario for Jungle Exploration



The design process for a smart classroom learning environment relies on a smart classroom learning system oriented towards information technology, which delivers real-time learning resources, collects student data, facilitates instant peer evaluation, pushes adaptive game-based exercises, and dynamically displays progress of answering questions. It also conducts visual analysis of quiz scores and survey results, captures and shares videos in real time.

The learning process design encompasses pre-class, in-class, and post-class stages. In the pre-class phase, students preview the material, draw perpendicular lines to given straight lines, take photos, and upload them. They share videos demonstrating their drawing process, identify uncertainties in their methods, and proceed to the next stage of learning with these questions in mind.

During class, students engage in learning through game scenarios created to establish a learning context. They interactively learn by completing tasks and practicing within these scenarios. Post-class, students enter a personalized student space where they promptly conduct self-assessment and reflection. The learning system then pushes out supplementary exercises to reinforce what they have learned, enabling them to consolidate their knowledge through extended practice.

5. Results

5.1 Pretest-Posttest Design with a Paired T-test

According to tracking data from the "Teaching Analysis Center" module within the smart classroom learning system, the overall class average for correct rates on two quizzes improved from 91.7% to 94.5%, indicating a significant enhancement in students' mastery of knowledge.

This study utilized IBM SPSS Statistics to conduct a paired-sample t-test on the students' scores from the pre- and post-assessments in order to examine the differences in their academic performance. The results are presented the table 1.

Table 1: Paired-sample t-test results for Case 2's pretest and posttest scores.

	Paired Differences					t	df	Sig.
	Mean	SD	SE	95% CI				
				Lower	Upper			
Pre-post test	-2.85714	8.34784	1.28810	-5.45851	-.25577	-2.218	41	.032

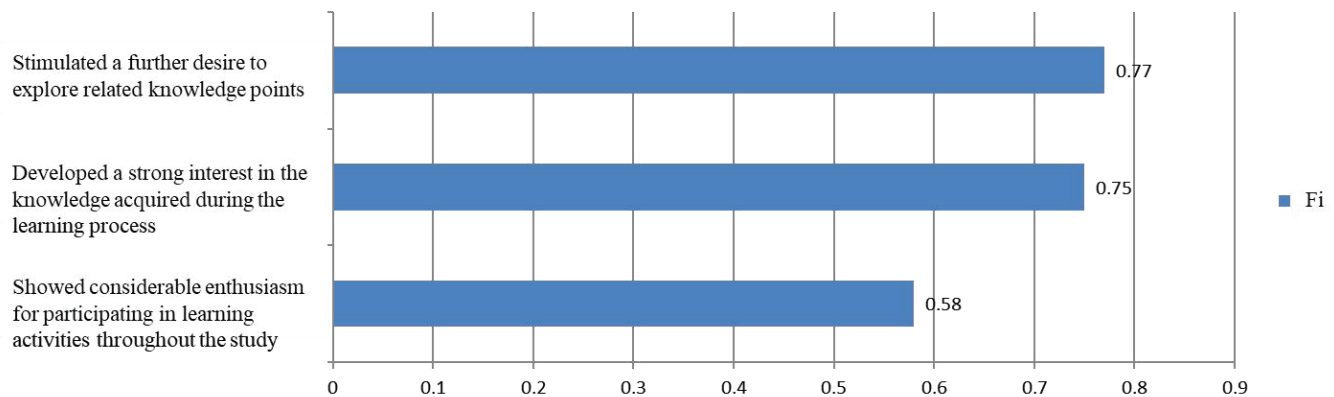
From the results of the paired-sample t-test comparing the pretest and posttest scores, it can be observed that the probability of a significant difference (Sig. [two-tailed]) = 0.032 is less than 0.05. Consequently, there is a statistically significant difference between the pretest and posttest scores. The mean score difference is -2.857, indicating that the average posttest score was higher than the average pretest score. This demonstrates that implementing a smart classroom learning model and strategies in teaching has significantly improved students' learning quality.

5.2. Survey on Enhancing Personalized Learning Engagement

The data from the survey on "enhancing personalized learning interest" among students in the mathematics lesson "drawing perpendicular lines" have been visually rendered by the smart classroom learning system.

The system's statistical results show that for the dimension of "enhancing personalized learning interest," the response rates (Fi) for all items are greater than 0. This indicates that the application of intelligent classroom learning models and strategies oriented towards information technology significantly boosts students' interest in personalized learning. Based on observations, students have reported being effectively engaged by learning activities during the pre-class, in-class, and post-class stages. They perceive the knowledge they acquire to be personally meaningful and express overall satisfaction with their learning process. Moreover, they demonstrate an aptitude for adapting to this mode of study.

Fig. 5. Visualization of the Score Rate for Enhancing Personalized Learning Interest

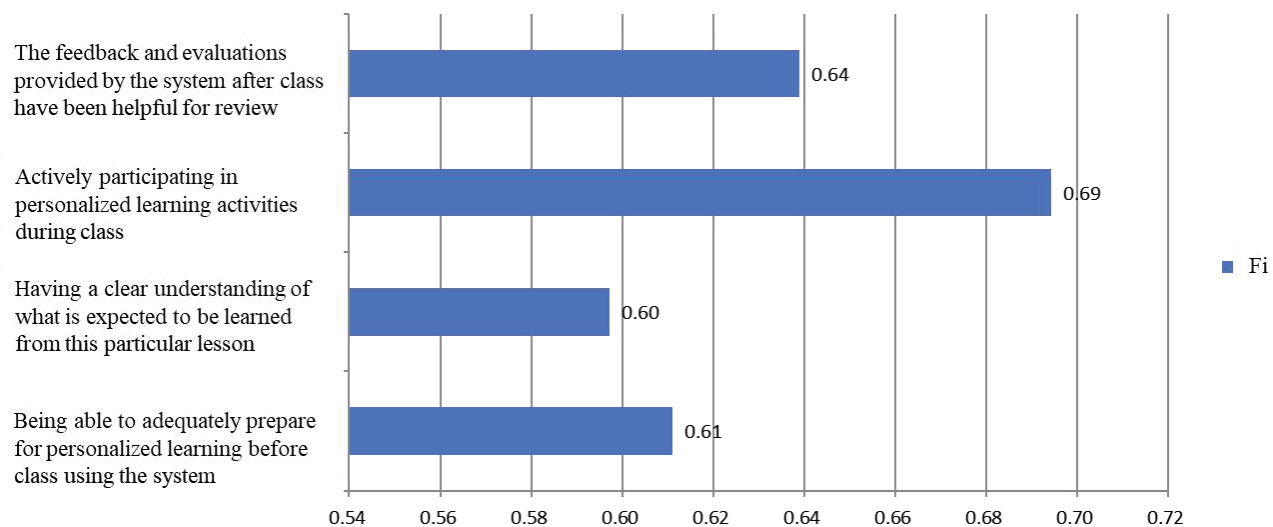


5.3 Optimizing Personalized Learning Process Survey on Drawing Perpendicular Lines

Student survey data on “Optimizing Personalized Learning Processes” in the math lesson “Drawing Perpendicular Lines” has been visually presented through an intelligent classroom learning system as shown in the figure below.

The statistical results from the system data indicate that for the dimension of optimizing personalized learning processes, the scores (Fi) for each item are all greater than 0. This suggests that the application of smart classroom learning models and strategies effectively optimizes students’ learning processes, significantly enhancing their learning initiative and fostering an increase in academic self-confidence.

Fig. 6. Visualization of the Score Rate for Optimizing Personalized Learning Process



5.4 Analysis of Student Learning Ability Survey Data

In a smart classroom learning environment designed for information education, teachers and students employed a specific learning mode and strategy in a math lesson titled “Drawing Perpendicular Lines.” This learning mode and strategy integrated the capabilities of the smart classroom system not only during the instructional phase but also for post-lesson evaluation. Following the lesson, the teacher utilized the intelligent classroom learning system to investigate the improvement in learning abilities among all 36 students.

All 36 students participated, indicating high levels of engagement and willingness to provide feedback. The 100% response rate and validity rate suggest that the data collected were reliable and representative of the class’s experience. Upon analyzing the data, it was found that across all six critical aspects of learning—personalized learning ability (the capacity to learn at an individual pace and style), autonomous inquiry ability (ability to ask questions and seek answers independently), knowledge construction ability (constructing meaning from new information), collaborative interaction ability (working together with peers to solve problems), information resource innovation ability (creatively utilizing and contributing to digital resources), and learning evaluation ability (assessing one’s own progress and understanding)—the average score rates exceeded 0.5.

This threshold value indicates a significant improvement in these skills among students when compared against some hypothetical midpoint or baseline. It signifies that the smart classroom model and its associated strategies were successful in cultivating advanced cognitive, social, and technical competencies necessary for effective learning in the digital age. The findings underscore the potential of technology-integrated classrooms to enhance the overall quality and depth of education by empowering students to be active students who can navigate complex information environments and work collaboratively in solving real-world problems.

Table 2: Questionnaire Survey Data

Dimensions	Indicator	5	4	3	2	1	Fi
Personalized Learning Abilities	Actively search for learning resources during the learning process	16	10	10	0	0	0.83
	Proactively share personal learning resources with classmates during the learning process	16	12	8	0	0	0.84
	Obtain needed learning resources through system notifications during the learning process	28	4	4	0	0	0.93
	Analyze the learning resources obtained during the learning process	26	6	4	0	0	0.92
	Master the knowledge to be learned during the learning process	24	8	4	0	0	0.91
	Learn and grasp knowledge at a relatively fast pace during the learning process	20	4	12	0	0	0.84
	Apply the mastered knowledge to solve problems within the learning process	15	13	8	0	0	0.84
Autonomous Inquiry Abilities	Actively identify learning objectives during the learning process	24	8	4	0	0	0.91
	Express personal learning needs proactively in the learning process	22	9	5	0	0	0.89
	Adjust the learning pace based on system feedback at appropriate times during the learning process	26	7	3	0	0	0.93
	Improve study methods independently within the learning process	21	9	5	1	0	0.88
Knowledge Construction Abilities	Rapidly acquire required knowledge during the learning process	26	7	3	0	0	0.93
	Analyze and synthesize knowledge effectively during the learning process	21	9	5	1	0	0.88
	Approach problems from multiple perspectives while learning	21	9	6	0	0	0.88
	Identify problems proactively and apply learned knowledge to solve them during the learning process	21	9	5	1	0	0.88
Collaborative Interaction Abilities	Actively communicate with peers and teachers during the learning process	24	8	4	0	0	0.91
	Proactively propose personal viewpoints in the learning process	22	8	6	0	0	0.89
	Humbly listen to and accommodate differing opinions from peers during the learning process	23	8	5	0	0	0.90

Dimensions	Indicator	5	4	3	2	1	Fi
Collaborative Interaction Abilities	Share learning experiences actively throughout the learning process	23	9	4	0	0	0.91
	Utilize system tools and technologies to complete collaborative tasks during the learning process	22	10	4	0	0	0.90
Information Resource and Innovation Ability	Design information resources within the learning process	22	8	6	0	0	0.89
	Create and finish the production of information resources during the learning process	21	8	7	0	0	0.88
	Share information resources during the learning process	23	10	3	0	0	0.91
Learning Assessment Skills	Analyze their own learning level based on system evaluations during the learning process	16	11	6	3	0	0.82
	Objectively assess others' performances through the system during the learning process	18	8	6	5	0	0.83
	Proactively participate in learning evaluation activities within the system during the learning process	14	12	8	2	0	0.81

5.5 Feedback on Smart Classroom Learning Experience

Upon completion of the learning activities, the teacher leveraged the real-time feedback and evaluation functions of the smart classroom by posting a discussion task on the "Teacher's Space," which said "Please share your learning experience from this class using the PMIQ diagram." Students were required to complete this reflection task in their respective "Student Spaces" on the same day. The teacher then reviewed the entire class's feedback on their learning experience in the discussion area. According to the feedback received, the majority of students had a positive learning experience, acquired new knowledge, and reported an increased interest in learning.

Student gz17 commented: "I have learned knowledge and would also like to learn how to draw parallel lines."

Student gz05 commented: "I have learned how to locate points on a line and draw perpendicular lines from points outside the line."

Student gz17 commented: "In the learning activity, I have mastered the method of drawing perpendicular lines and even shared a video on how to draw them with my classmates."

Student gz04 commented: "Through game practice, I have learned how to draw perpendicular lines, and now I want to learn how to draw parallel lines."

Student sgz01 said: "I have learned how to draw perpendicular lines."

In summary, students reported their progress in geometry skills where they each acquired the technique for drawing perpendicular lines. Based on the above information, it can be deduced that students have successfully acquired the skill of drawing perpendicular lines through various interactive learning approaches and have demonstrated a strong interest in new concepts such as the method of drawing parallel lines, along with an active commitment to continued learning. This feedback provides valuable insights for educators, enabling them to design subsequent teaching content and activities tailored to students' actual needs and points of interest, thereby fulfilling their desire for a more comprehensive and in-depth study of geometry.

6. Discussion

6.1 Improving Students' Learning Quality

This paper conducts a single-group experiment on the case, employing pre-tests and post-tests, with the differences in mean scores between the two tests being -4.924, -2.857, and -2.28571, respectively. The data show statistically significant differences ($p < 0.05$), indicating that after implementing smart classroom learning modes and strategies, students' learning

quality has been enhanced during their learning process within an information-based smart classroom. This research outcome aligns with previous studies. For instance, Ngendahayo et al. (2023) found that promoting technology self-efficacy, perceived usability, and learning satisfaction in a smart teacher environment can contribute to improved academic performance (Ngendahayo et al., 2023). Similarly, Shen et al. (2022) also discovered that in a smart classroom setting, students who utilized VR-assisted teaching applications for learning outperformed those using traditional teaching methods in terms of academic achievement (Shen et al., 2022).

6.2 Enhancing Students' Personalized Learning Abilities

In this paper, the improvement of students' personalized learning abilities is individually examined through a unidimensional scale survey in the case study. The response rate (F_i) for each aspect exceeds 0.5, indicating a significant enhancement in students' ability to acquire and utilize personalized learning resources. This improvement is manifested specifically in the following aspects. Students can proactively search for learning resources during the learning process, actively share their own learning resources with classmates, access needed learning resources via system recommendations, and analyze the learning resources they obtain. There is an increase in the rate of mastering personalized knowledge, where students can effectively grasp the required knowledge at a faster pace and apply this knowledge to solve problems. Yu et al. (2022) also supports this conclusion in their research, which reveals that student engagement significantly increases within smart classrooms. Meanwhile, Li et al. (2023) implemented real-time feedback mechanisms in the teaching process, providing teachers with immediate information support and enabling them to offer personalized support to students. By doing so, these studies affirm that smart classroom environments can indeed foster and enhance students' personalized learning abilities.

6.3 Enhancing Students' Autonomous Inquiry Abilities

This paper evaluates the improvement of students' autonomous inquiry abilities in the case study using a unidimensional scale survey, with all response rates (F_i) exceeding 0.5. This demonstrates that applying smart classroom learning models and strategies significantly boosts students' capacity for autonomous inquiry. Specifically, these improvements are reflected in the following aspects. Students can proactively identify their learning objectives during the learning process. They can express their individual learning needs actively. They can adjust their learning pace according to system feedback at appropriate times. They can improve their learning methods independently. Lei et al. (2022), on the other hand, constructed an evaluation index system based on the Pressure-State-Response (PSR) model. By incorporating classroom assessment, after-class assessment, and feedback into this system, they effectively promoted students' initiative and enthusiasm in learning, further supporting the idea that smart classrooms can indeed foster the development of students' autonomous inquiry skills.

6.4 Enhancing Students' Knowledge Construction Abilities

In this paper, the improvement of students' knowledge construction abilities in the case study is investigated using a unidimensional scale survey. The response rate (F_i) for each item exceeded 0.5, which indicates that employing smart classroom learning models and strategies has significantly enhanced students' ability to construct knowledge. This enhancement is manifested concretely in the following aspects. Students can swiftly access required knowledge. They can analyze and synthesize the acquired information effectively. They demonstrate multi-perspective thinking when facing problems and proactively identify issues, applying their learned knowledge to solve them. Previous study also supports this conclusion in quasi-experimental research, finding that using smart classrooms for instruction leads to a notably significant improvement in students' problem-solving abilities, showcasing the most prominent advancement effects among various learning outcomes (Cheng et al., 2023).

6.5 Enhancing Students' Collaborative Interaction Abilities

In this paper, the enhancement of students' collaborative interaction abilities in the case study is assessed through a unidimensional scale survey, where all response rates (F_i) exceed 0.5. This suggests that the application of smart classroom learning models and strategies significantly improves students' ability to collaborate and interact effectively. Specifically, these improvements are evidenced by four aspects. Students actively communicate with their peers and teachers. They proactively express their own opinions. They humbly listen to and accommodate different perspectives from their peers. They willingly share experiences and use system technologies to complete collaborative inquiry tasks. These findings align with

those of Yang et al. (2017), whose research showed that students in technology-rich classrooms (TRCs) tend to engage more deeply in both individual and collaborative learning compared to those in multimedia classroom environments. This study thus confirms that using smart classrooms can indeed foster enhanced collaborative interaction skills among students.

6.6 Enhancing Students' Information Resource and Innovation Abilities

In this paper, the enhancement of students' collaborative interaction abilities is examined through a unidimensional rating scale in each case study, where all scores (F_i) exceed 0.5. This signifies that employing an information-based smart classroom learning model and strategies has significantly boosted students' ability to collaborate and interact effectively. Specifically, this improvement manifests itself in students demonstrating. The initiative to communicate with their peers and teachers. A willingness to proactively express their own ideas. An open-mindedness to listen respectfully and accommodate differing opinions from classmates. An eagerness to share experiences and utilize system technologies to complete collaborative investigative tasks. These findings are consistent with existing studies, which revealed that in technology-rich classrooms (TRCs), students tend to engage more deeply in both individual and collaborative learning compared to those in multimedia classroom environments (Yang et al., 2017). Therefore, this research confirms that implementing smart classroom approaches can indeed lead to significant advancements in students' collaborative interaction skills.

6.7 Enhancing Students' Information Resource and Innovation Abilities

In this paper, the improvement of students' information resource and innovation capabilities in each case study is assessed using a unidimensional scale survey with all response rates (F_i) surpassing 0.5. Implementing information-based smart classroom learning models and strategies significantly boosts students' abilities to innovate with information resources, specifically evidenced by their capacity to design, create, and share information resources. This finding parallels the results of Nguyen et al. (2022), who discovered that projects incorporating intelligent learning concepts and innovative methods can foster a positive learning environment that enhances students' thinking abilities, knowledge, skills, and ultimately, their creativity.

6.8 Improving Students' Learning Assessment Skills

In this study, the development of students' learning assessment skills within each case was also measured using a single-directional rating scale, where the rate of success (F_i) exceeded 0.5 for all items. Applying information-oriented smart classroom learning models and strategies has led to significant advancements in students' ability to evaluate their own learning, objectively assess others' performances, and proactively engage in learning evaluations. These outcomes align with existing research findings. Previous researchers designed a method for creating an AI-driven English Language and Literature smart classroom along with its application assessment (Zhang et al., 2023). This approach facilitated students' familiarity with English contexts and cultural backgrounds, thereby leading to comprehensive improvements in their language proficiency and fostering their ability to conduct self and peer assessments effectively.

7. Conclusion

Through the examination of empirical data derived from an experiment within primary school mathematics lessons in a technologically advanced smart classroom context, the research findings underscore the substantial positive impact that these environments can exert on students' learning outcomes. The statistical measure represented by the score rate F_i serves as compelling evidence, highlighting an upward trend in students' multifaceted learning competencies across various dimensions. Synthesizing student feedback on their learning experiences and observations of teachers' practices, it is evident that the application of information-directed smart classroom learning models and strategies can effectively improve the overall learning quality for students. It also boosts students' personalized learning interests, optimizes their individualized learning processes, and elevates their abilities in personalized learning, autonomous inquiry, knowledge construction, collaborative interaction, information resource innovation, and learning evaluation.

Looking ahead, future research endeavors should delve deeper into the realm of intelligent teaching modes and instructional strategies underpinned by advanced algorithms such as machine learning and deep learning. These studies aim to validate and optimize the practical effectiveness of these emerging models and strategies, further revolutionizing education within smart classrooms and beyond.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research on Curriculum Reform Pathways for Cultivating Family Education Guidance Competence in Primary Education Teacher Candidates from the Perspective of Curriculum Ideological and Political Education

Junyan Wang*

Teachers College, Xi'an University, Xi'an, 710065, China

*Corresponding author: Junyan Wang

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Abstract: This study systematically explores the cultivation pathways for family education guidance competence among primary education teacher candidates based on the concept of curriculum ideological and political education. By analyzing policy requirements such as the “Professional Competence Standards for Teacher Candidates in Primary Education (Trial)” (hereafter referred to as the “Competence Standards”), it elucidates the value significance of integrating curriculum ideological and political education into the cultivation of family education guidance competence. It proposes the construction of a tripartite curriculum objective system encompassing “value guidance-methodological training-practical application.” Addressing current issues in cultivation, including fragmented curricula, insufficient faculty resources, and monolithic resources, reform pathways are proposed from three dimensions: curriculum design, faculty development, and resource expansion. These involve constructing a modular curriculum system, building a “teaching-research integrated” instructional team, and establishing a “multi-dimensional collaborative” resource platform. The research indicates that organically integrating curriculum ideological and political education throughout the entire process of cultivating teacher candidates’ family education guidance competence facilitates the unification of knowledge transmission, competence development, and value shaping, providing theoretical reference and practical paradigms for teacher education reform in the new era.

Keywords: Curriculum Ideological and Political Education; Primary Education Teacher Candidates; Family Education Guidance Competence; Curriculum Reform

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1.Introduction

Primary education constitutes the cornerstone of the national education system. The comprehensive literacy and educational competence of primary school teachers play a foundational role in students’ holistic growth and value formation. ^[1] In the context of the new era, cultivating future teachers who possess solid professional knowledge, profound professional ethics and sentiments, and outstanding practical capabilities has become the core objective for the high-quality development of primary education programs. In 2021, the Ministry of Education promulgated the “Professional Competence Standards for Teacher Candidates in Primary Education (Trial)” (hereafter referred to as the “Competence Standards”), providing clear

professional norms and competence guidance for teacher candidate cultivation.^[1] The “Competence Standards” particularly emphasize that teacher candidates should “master curriculum-based educational methods and strategies” and be capable of “integrating ideological and political education resources within the curriculum according to its characteristics,^[2] combining knowledge acquisition, competence development, and moral cultivation.”^[3] This requirement not only highlights the pivotal role of “curriculum ideological and political education” in teacher education but also propels “how to cultivate primary school teachers adapted to the demands of basic education reform in the new era” to the forefront of professional talent cultivation.^[4] Against this backdrop, systematically integrating the concept of curriculum ideological and political education into the professional competence cultivation system for teacher candidates has become an educational practice task characterized by contemporaneity, dynamism, and relevance.^[5] Within this context, effectively enhancing teacher candidates’ family education guidance competence through curriculum construction,^[6] enabling them to implement the fundamental task of fostering virtue through education in future home-school collaboration, represents a crucial breakthrough for talent cultivation from the perspective of curriculum ideological and political education. Establishing scientific curriculum objectives and practical pathways is key to achieving this integration.

2.The Value Significance of Integrating Curriculum Ideological and Political Education into the Cultivation of Family Education Guidance Competence in Teacher Candidates

2.1 Curriculum Ideological and Political Education Construction as an Inherent Requirement for Implementing Connotative Development in Teacher Education

The “Opinions of the Central Committee of the Communist Party of China and the State Council on Comprehensively Deepening the Reform of Teacher Team Construction in the New Era” explicitly state that teachers undertake the special mission of national public officials and must strengthen their “national responsibility, political responsibility, and social responsibility.” Primary education programs possess dual attributes of disciplinary nature and educational nature, inherently possessing ideological and political connotations guided by the cultivation of professional ethics and rooted in socialist core values in terms of value orientation.^[7] Therefore, ideological and political education is not an external add-on task to professional teaching but rather the intrinsic gene and value axis of talent cultivation. The nurturing essence and composite characteristics of teacher education determine that its curriculum must reflect the spirit of the times and practical orientation. In the construction of curriculum ideological and political education, guiding teacher candidates to deeply comprehend the spirit of educators and reflect on real-world educational issues not only contributes to forming their firm professional beliefs and ethical sentiments but also enhances their identification with the cause of socialist education with Chinese characteristics. In this process, cultivating family education guidance competence as an important component of teacher candidates’ ideological and political literacy and practical competence can enrich their professional experiences, deepen their understanding of the mission of “educating people for the Party and nurturing talent for the country,” and constitutes an essential element of realizing the “Three-All Education” (三全育人) framework.^[8]

2.2 Curriculum Ideological and Political Education Construction as the Core Lever for Promoting Talent Cultivation Reform in Teacher Education

The issuance of the “Guiding Outline for Curriculum Ideological and Political Education Construction in Higher Education Institutions” in 2020 established the fundamental principle of “fostering virtue through education” for professional courses in education. It explicitly proposed to “focus on strengthening teacher ethics and style education, highlight moral cultivation through classroom teaching, role modeling, and rule-based ethics, and guide students to establish the professional ideal of ‘learning to be a teacher and acting as a role model’.”^[9] This requirement points the way for the curriculum system construction of primary education programs and prompts deeper reflection: during the cultivation of teacher candidates’ family education guidance competence, how can value guidance be organically integrated into knowledge transmission and skill training, enabling teacher candidates not only to master home-school communication methods and strategies but also to form professional sentiments centered on “educating with virtue and nurturing with love.” Integrating the cultivation of the educator’s spirit throughout the entire process of developing family education guidance competence has become a key focal

point in the cultivation of primary education teacher candidates from the perspective of curriculum ideological and political education.

2.3 Curriculum Ideological and Political Education Construction as the Intrinsic Pathway for Integrating the Cultivation of Family Education Guidance Competence in Teacher Candidates

The “Professional Competence Standards for Teacher Candidates in Primary Education (Trial),” centered on the cultivation goal of the “Four Haves” (四有) good teacher, systematically constructs a four-in-one competence framework encompassing ethical practice competence, teaching practice competence, comprehensive educational competence, and autonomous development competence, prominently emphasizing the foremost standard of teacher ethics and conduct. In cultivating family education guidance competence, ethical practice is the prerequisite, comprehensive education is the goal, and teaching practice and autonomous development are the guarantees. This intrinsic logic highly aligns with the tripartite educational philosophy of curriculum ideological and political education: “value shaping, knowledge transmission, and competence cultivation.” Curriculum ideological and political education construction is precisely the effective pathway to break through the internal connections between these four competencies and achieve their organic integration.^[10] It can guide teacher candidates, in the study and practice of family education, not only to master guidance methods and techniques but also to deeply understand the humanistic care and social responsibility of education, enhancing their professional identity and emotional experience in authentic home-school collaborative contexts, thereby truly realizing the educational effect of “the unity of knowledge and action.”^[11]

3. Curriculum Construction Objectives for Cultivating Family Education Guidance Competence in Primary Education Teacher Candidates from the Perspective of Curriculum Ideological and Political Education

Guided by the concept of curriculum ideological and political education, the cultivation of family education guidance competence in teacher candidates should transcend the limitations of singular skill training. It necessitates constructing a comprehensive curriculum objective system led by value rationality, supported by methodology, and aimed at practical competence. This system aims to achieve the organic unification of knowledge transmission, competence development, and value shaping, specifically encompassing the following three dimensions:

3.1 Establishing a Family Education Guidance View Centered on Fostering Virtue Through Education

The primary objective of curriculum construction is to guide teacher candidates to deeply comprehend the social value and educational significance of family education from the heights of national strategy and the essence of education. Teacher candidates should firmly establish the public responsibility consciousness that “family education is a ‘national affair’ rather than merely a ‘family matter,’” consciously adopt socialist core values as the value criterion, and internalize the fundamental task of “fostering virtue through education” stipulated in the “Family Education Promotion Law” as the value principle guiding their practice.^[12] Through curriculum learning, teacher candidates need to form scientific views of children, education, and home-school collaboration, enabling them in future professional practice to effectively guide parents to abandon utilitarian educational tendencies, focus on cultivating their children’s ideological and moral character, sound personality, and comprehensive literacy, and earnestly shoulder the mission of “educating people for the Party and nurturing talent for the country.”

3.2 Systematically Mastering Family Education Guidance Methods Integrating Scientificity and Ethicality

The curriculum must enable teacher candidates to systematically construct a methodological system for family education guidance. This system not only includes diagnostic and analytical techniques based on educational and psychological theories but also emphasizes the educational ethics and humanistic care that should be upheld during the application of these methods. Teacher candidates should proficiently employ professional methods such as empathetic communication, active listening, and case study discussions, and demonstrate professional wisdom and benevolence when addressing typical issues like academic difficulties, parent-child conflicts, and internet usage.^[13] The curriculum needs to focus on cultivating teacher candidates’

value judgment and ethical decision-making abilities in complex situations, ensuring their guidance methods are both scientifically effective and consistently compliant with teacher ethics norms and educational equity principles, achieving the unity of instrumental rationality and value rationality.

3.3 Forming Collaborative Educational Practical Competence in Integrating Home-School-Community Resources

The ultimate goal of the curriculum is to cultivate teacher candidates' comprehensive practical competence in integration, design, and implementation, enabling them to play a leading professional role within the home-school-community collaborative education system. Teacher candidates should transcend the unidirectional "teacher guiding parents" model and develop into organizers and promoters of collaborative education. The curriculum should, through situational simulations, project design, and field practice, train their ability to design and implement home-school co-education activities, link community cultural resources, and initially construct educational communities.^[14] The achievement of this goal signifies that teacher candidates can creatively apply internalized value concepts and mastered professional methods to authentic, dynamic educational fields, fundamentally practicing the "Three-All Education" concept and enhancing the effectiveness of comprehensive education.^[15]

4. Curriculum Reform Pathways for Cultivating Family Education Guidance Competence in Primary Education Teacher Candidates from the Perspective of Curriculum Ideological and Political Education

To organically integrate the concept of curriculum ideological and political education throughout the entire process of cultivating teacher candidates' family education guidance competence, a systematic and operable curriculum implementation system needs to be constructed. Based on current issues in the cultivation model, such as fragmented curricula, insufficient practical experience among faculty, and monolithic teaching resources, this study proposes the following reform pathways from three dimensions: curriculum structure, faculty team, and teaching resources:

4.1 Optimizing Curriculum Design, Constructing a "Tripartite" Modular Curriculum System

Curriculum design serves as the systematic carrier for competence cultivation. The difficulty in curriculum ideological and political education lies in ensuring that metaphysical value perceptions do not merely remain at the superficial cognitive level of students but truly become the intrinsic driving force guiding their specific behaviors. Although "professional ethics" is fundamental for teacher candidates, student groups primarily residing in university campuses for extended periods find it difficult to fundamentally empathize with educational sentiments due to a lack of practical experience. For a long time, the phenomenon of theoretical instruction being disconnected from practical teaching has been prevalent in the cultivation process of teacher candidates' family education guidance competence. The development of practical courses has lagged, theoretical instruction and practical scenarios are isolated and difficult to integrate, and educational theoretical knowledge cannot be timely and effectively transformed into the practical competence of teacher candidates.^[16] Courses related to family education for teacher candidates often exhibit fragmentation, failing to achieve the organic unity of value, method, and practice. Therefore, achieving complementarity and transformation between "conceptual ethics" and "action-oriented ethics" in curriculum teaching is crucial. A modular curriculum system with the logical main line of "value guidance-methodological training-practical application" should be constructed.^[17]

Value Guidance Module: Aims to solidify the value foundation of teacher candidates in family education. By offering courses such as "Philosophical Foundations of Family Education" and "Educational Ethics and Home-School Cooperation," it systematically expounds upon the social attributes, cultural functions, and political implications of family education, strengthening their understanding and identification with the core spirit of the "Family Education Promotion Law" and socialist core values, laying the value foundation for subsequent scientific family education guidance.

Methodological Training Module: Focuses on the systematic construction of professional competence. Through courses like "Methods and Techniques of Family Education Guidance" and "Ethics and Art of Home-School Communication," it systematically teaches professional skills such as family assessment, communication strategies, activity design, and crisis intervention. It introduces typical ethical dilemma cases to cultivate teacher candidates' professional judgment that achieves

unity in scientificity, standardization, and humanism in complex situations.

Practical Application Module: Emphasizes the transformation of theory into practice. It explicitly sets family education practice tasks during educational observation and internships, requiring teacher candidates to complete practical assignments such as home visit logs, parent-teacher meeting scheme design, and simulated mediation of home-school conflicts. This enables them to comprehensively apply learned value concepts and operational methods in authentic educational settings, achieving the unity of knowledge and action.

4.2 Strengthening Faculty Development, Building a “Teaching-Research Integrated” Composite Instructional Team

Teachers are the key agents in curriculum implementation. Addressing prevalent issues in the current faculty, such as disconnection between theory and practice and insufficient competence in curriculum ideological and political education teaching, efforts should be made to build a composite faculty team possessing theoretical literacy, practical wisdom, and awareness of ideological and political education.

Optimize the composition of instructors by implementing a “university-primary school” dual-mentor system. Renowned primary school head teachers and moral education backbone teachers should be appointed as practical mentors, participating alongside university full-time teachers in curriculum design, teaching guidance, and practical evaluation to achieve deep integration of theoretical perspectives and practical experience.

Implement a faculty enhancement plan for ideological and political education teaching competence. Through regular curriculum ideological and political education workshops and family education thematic seminars, focus on improving teachers’ ability to excavate curriculum ideological and political elements and design value-guided teaching plans.

Increase the participation of primary school teachers in curriculum construction, utilizing alumni’s professional experience and educational sentiments to inspire educational sentiments in teacher candidates, laying the foundation for their professional competence cultivation. Promote the construction of structured teaching teams by forming course groups around core courses, engaging in collective lesson preparation, case database development, and teaching research to achieve joint research, sharing, and problem-solving of teaching and practical issues, supporting high-quality teaching with high-level research.

4.3 Expanding Curriculum Resources, Constructing a “Multi-Dimensional Collaborative” Open Resource Platform

The cultivation of family education guidance competence in primary education teacher candidates requires the joint efforts of relevant entities such as universities, primary schools, and society. As a systematic project, ideological and political education is closely related to the coordination and cooperation of these entities. Existing resource utilization in primary education curriculum construction is relatively monolithic, primarily centered on university education, lacking in-depth exploration of various social resources and resources within the school system. The use of resources inside and outside the university and across disciplines is fragmented, characterized by spatial boundaries and disciplinary barriers. Limitations in resource source channels and application channels result in superficial application of various resources. Teaching resources are a crucial guarantee for achieving curriculum objectives. To overcome limitations such as monolithic resource forms, scarcity of cases, and disconnection from reality, it is necessary to systematically develop and integrate a three-dimensional, open teaching resource repository. Utilize information technology, relying on cloud platforms, virtual simulation, etc., to establish online-offline action communities with primary schools. Form a cultivation model of “online resource sharing + offline interactive co-education,” embedding primary school classroom teaching into university classrooms. Break down barriers between physical and information spaces of classroom teaching, achieve seamless connection between university and primary school classrooms, fully link theoretical teaching with authentic primary school practice, promote the integration of classroom teaching time and space, and provide panoramic teaching scenarios for teacher candidates.

Focus on building a localized case database. Collaborate with frontline primary schools and educational research institutions to jointly develop normative teaching cases covering typical situations such as home-school communication, guidance for students with special needs, and parent-child relationship adjustment, ensuring the authenticity, representativeness, and teaching applicability of the cases. Construct a digital resource platform, integrating high-quality MOOCs, expert lectures,

virtual simulation experiments, and other resources to support students' autonomous learning and immersive experiences. Build collaborative education practice bases. Establish stable cooperative relationships with high-quality primary schools and model communities, forming an integrated practical teaching chain of "observation-observation-internship." Extend curriculum learning to authentic educational sites, enabling teacher candidates to deepen their understanding of home-school-community collaborative education through immersive experiences, comprehensively enhancing their comprehensive practical competence and educational sentiments.

Conclusion

This study has systematically argued for the necessity and feasibility of deeply integrating the concept of curriculum ideological and political education into the cultivation of family education guidance competence among primary education teacher candidates. In response to the structural dilemmas within the current cultivation system—namely fragmented curricula, insufficient practical experience among faculty, and monolithic teaching resources—this research has innovatively constructed a tripartite curriculum objective system encompassing "value guidance, methodological training, and practical application." Building upon this framework, specific reform pathways are proposed from three dimensions: curriculum structure, faculty development, and teaching resources. These include the construction of a modular curriculum system, the development of a "teaching-research integrated" instructional team, and the establishment of a "multi-dimensional collaborative" resource platform.

This systematic pathway is designed to break down the barriers between theoretical instruction and practical application, achieving the organic transformation from "conceptual ethics" to "action-oriented ethics." It ensures that teacher candidates not only master professional skills but also internalize the core values of "fostering virtue through education," thereby enhancing their professional identity and mission. The research demonstrates that this systematic curriculum reform paradigm not only provides a practical blueprint for effectively enhancing the professional leadership of teacher candidates in home-school-community collaborative education in the new era, but also offers a reference solution with both theoretical depth and practical validity for advancing curriculum ideological and political education in teacher education and fulfilling the fundamental task of fostering virtue through education.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Teaching Innovation and Competency Development in the Age of Generative AI: A Case Study of the Course “Online Communication and Public Opinion Supervision”

Zhuo Wang*

School of digital media, Guangzhou University of Software, Guangzhou, 510900, China

*Corresponding author: Zhuo Wang

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Abstract: Generative Artificial Intelligence (AIGC) has emerged as a disruptive force, fundamentally altering digital communication and information ecosystems. This development poses significant challenges to public opinion supervision, as the lines between authentic and synthetic content are increasingly blurred. Traditional communication curricula are often unprepared to address the threats of deepfakes, automated manipulation, and authenticity crises. This paper presents a pedagogical case study of a redesigned undergraduate course, “Online Communication and Public Opinion Supervision,” at a teaching-focused university. To address AIGC-related challenges, a series of teaching innovations were implemented. These included updated curriculum modules on AIGC, adversarial “red team vs. blue team” simulations, AI-augmented project-based assignments, and oral crisis response drills. The aim was to cultivate four core competencies: technical understanding, critical discrimination, ethical judgment, and human-AI collaboration. Empirical outcomes from the course implementation were evaluated. Significant improvements in students’ analytical performance, ethical reasoning, and engagement were observed. This case study provides insights into effective pedagogical strategies. It offers a model for adapting communication and media education to prepare students for the complexities of the generative AI era.

Keywords: Generative AI; AIGC; Teaching Innovation; Pedagogy; Public Opinion Supervision; Online Communication; AI Literacy; Competency Development

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1.Introduction

Generative Artificial Intelligence (AI), frequently identified by the acronym AIGC (AI-Generated Content), has rapidly transitioned from a niche technical concept to a disruptive mainstream force in digital communication. Since late 2022, the widespread availability of advanced generative models, such as large language models (LLMs) and diffusion-based image generators, has empowered a global user base to create highly realistic text, images, audio, and video with unprecedented ease^[1]. This technological leap is fundamentally blurring the line between authentic, human-created content and synthetic, machine-generated media. As a consequence, traditional cues for establishing credibility and trust in the digital sphere are being systematically undermined, presenting a profound societal challenge. The pervasive integration of AIGC has been noted by scholars as becoming “deeply embedded” within human communication processes. A new “GAI logic” is being introduced, which is actively reshaping established media structures, discourse norms, and the very economics of content

production. In practice, the societal impact is already being witnessed. AI-generated rumors, sophisticated deepfakes, and automated influence campaigns can escalate and influence real-world events at a velocity that outpaces traditional verification mechanisms. Such incidents, ranging from synthetic images of political events to fabricated audio of public figures, highlight an emerging and deepening crisis of authenticity in the public sphere^[2].

This disruptive influence of AIGC on the formation and flow of public opinion has drawn significant global concern from academics, policymakers, and industry leaders. Governments worldwide are beginning to respond with regulatory frameworks. For example, China's 2023 "Interim Measures for the Management of Generative AI Services" emphasizes a dual approach: promoting technological innovation while simultaneously mitigating societal risks. These measures explicitly require that AI-generated content must be accurate, reliable, and align with core societal values. Concurrently, international organizations and technology consortiums are stressing the urgent need to develop and implement robust safeguards to protect the global information ecosystem from malicious AIGC applications. Amid this fast-evolving and uncertain landscape, educators, particularly in the fields of media, communication, and journalism, face an urgent and complex challenge. Students—especially future media professionals, policymakers, and corporate communicators—must be adequately prepared to navigate, analyze, and responsibly supervise online public opinion in an age saturated with generative AI. Traditional curricula, often designed for the social media era, must be fundamentally rethought. Educational models must now account for new threat vectors, such as hyper-realistic deepfakes, algorithmically-driven bot networks, and the subtle biases embedded within AI models. Simultaneously, these curricula must also incorporate the new analytical tools and collaborative workflows that AIGC offers^[3].

This paper examines these multifaceted challenges and details the pedagogical responses developed within a specific academic context. A comprehensive case study of a redesigned undergraduate course, "Online Communication and Public Opinion Supervision," is presented. This course, a core requirement for New Media majors at a teaching-focused university, was recently and substantially revamped to address the AIGC revolution. The paper is structured as follows: First, a literature review is conducted to analyze the specific disruptions generative AI brings to the public opinion ecosystem, focusing on three key areas. Following this analysis, the core competencies that students must now acquire are identified and defined. Next, the core of the paper details the innovative teaching strategies that were designed and implemented. These strategies range from updated theoretical modules and adversarial "red team vs. blue team" simulations to project-based learning assignments integrated with AI tools. These strategies were explicitly designed to cultivate the previously identified competencies.

Subsequently, the empirical outcomes from the course are presented and analyzed. These observations, drawn from classroom exercises, assignment analysis, and qualitative student feedback, are used to evaluate the impact of the innovations on student performance, AI literacy, and engagement. The goal is to derive actionable insights into effective teaching innovations. These innovations should foster the critical, analytical, and ethical skills necessary for future media professionals. Ultimately, this case study aims to shed light on how university-level curriculum and pedagogy can be effectively adapted, ensuring that students are prepared to become competent and responsible supervisors of public opinion in the complex generative AI era.

2. The Disruptive Influence of Generative AI on Public Opinion Ecosystems

The public opinion and information ecosystem is being fundamentally and irreversibly transformed by the proliferation of generative AI. This transformation is not incremental; it represents a paradigm shift in how information is created, disseminated, and consumed. The influence of AIGC can be understood through several critical, interrelated challenges that strike at the heart of public discourse.

2.1 Authenticity and Credibility Crisis

Perhaps the most pervasive and immediate issue is the systemic erosion of epistemic trust in online content. Generative models are now capable of producing text, visuals, and audio that are indistinguishable from genuine, human-created content for the average user, and often for trained experts as well. This capability makes it increasingly difficult, and in some cases impossible, for both the general public and professional fact-checkers to verify authenticity at scale. As a result, highly sophisticated misinformation and disinformation can be injected directly into public discourse, bypassing traditional

journalistic gatekeepers and spreading rapidly through social networks. This phenomenon exacerbates the conditions of a “post-truth” environment, where objective facts are less influential in shaping public opinion than appeals to emotion and personal belief^[4]. A “liar’s dividend” has been warned of by scholars: a scenario where the mere existence of convincing fake content (like deepfakes) provides malicious actors with plausible deniability, allowing them to dismiss real events, authentic videos, or genuine documents as “fake.” This uncertainty further undermines public trust in foundational institutions, including media, government, and science.

Public opinion supervision, which as a discipline relies on the ability to establish a baseline of factual truth and hold actors accountable, faces a profound methodological challenge when factual reality itself becomes a disputed commodity. In one pertinent Chinese analysis, it was observed that AIGC-driven false information is effectively “hijacking social trust” by creating fractured cognitive pictures of reality among the populace, thereby manipulating discourse orientation for political or commercial gain. In short, a deep and persistent crisis of authenticity has been precipitated by generative AI. Citizens are left increasingly unable to trust digital content, and authentic information itself is at constant risk of being dismissed or distorted. Consequently, public opinion supervisors and media professionals must now learn to operate in an environment of chronic uncertainty, requiring a new suite of verification skills and technological tools.

2.2 Deepfakes and Synthetic Media Threats

A particularly acute and high-profile facet of the authenticity crisis is the rise of deepfakes and other forms of synthetic media. Deepfakes are hyper-realistic AI-generated videos or audio files that purport to show real people saying or doing things they never said or did. This technology moves beyond simple photo manipulation into the realm of behavioral and identity fabrication. Unprecedented and asymmetric risks to public discourse are posed by these technologies. These risks range from the targeted defamation of public figures and political candidates to the incitement of social conflict, diplomatic crises, or financial market manipulation.

By 2022–2023, the threat moved from theoretical to practical. Real-world instances began appearing with increasing frequency and sophistication. These included a widely circulated deepfake of Ukraine’s president seemingly issuing a surrender order, as well as forged videos of corporate CEOs making false announcements that briefly impacted stock prices. Each incident had the potential to sway public opinion or cause real-world panic before it could be authoritatively debunked. Deepfakes exploit the powerful cognitive bias that “seeing is believing.” They cause viewers to form strong, emotionally resonant memories of events that never occurred, making subsequent corrections less effective. Viewers are thus conditioned to doubt the veracity of even verified, authentic information. Beyond political and financial applications, the technology is also used to create non-consensual pornographic imagery, constituting a severe form of digital-age harassment and abuse^[5].

The threat to digital authenticity is therefore twofold. On one hand, the public may be comprehensively fooled by increasingly realistic fakes. On the other hand, a “reality apathy” may set in, where even truthful, verifiable documentation of real-world events (such as human rights abuses) is casually questioned or dismissed as a potential AI fabrication. Both outcomes are profoundly damaging to the integrity of public discourse and the function of a democratic society. It has been noted that people are now increasingly unable to reliably distinguish between AI-generated and authentic media. Human perception and traditional media literacy heuristics alone can no longer be relied upon to guard against manipulated content. This escalating technological arms race between synthesis and detection places new and urgent responsibilities on educators. Students must be taught the technical-social dynamics of deepfakes, how to detect them, how to respond to them in a crisis, and how to ethically manage the profound implications of AI-altered information.

2.3 Automated Opinion Manipulation

Generative AI also serves as a powerful accelerant, supercharging the scale, sophistication, and cost-effectiveness of automated information manipulation. In the previous era of social media (dubbed “social media manipulation 2.0”), orchestrated disinformation campaigns, such as those originating from “troll farms” or social bot networks, were often limited by the human labor required to craft plausible messages. These bots were often relatively easy to detect due to repetitive, simplistic, or non-contextual behaviors. Generative AI, however, enables “social media manipulation 3.0.” An avalanche of unique, context-aware, and tailored posts, comments, and even interactive conversational messages can now be produced by

AI-driven bots at a massive scale. These AI agents can flood social media platforms with particular narratives—a strategy known as agenda flooding or “computational astroturfing.” This activity is designed to create a false impression of grassroots consensus, manufacturing the appearance of widespread public support or opposition to a policy, brand, or idea.

It is explained that bots armed with generative AI can effectively “blur the line between human and machine.” Their ability to mimic human linguistic nuance, emotional expression, and interaction patterns makes it exceptionally challenging to discern automated accounts from real users. Public opinion can thus be swayed by systematically saturating information feeds with compelling, targeted, and seemingly “human” content. Notably, influence operations can be cheaply and efficiently scaled up by malicious actors—be they state-sponsored groups, political campaigns, or commercial entities. Recent analyses from think tanks indicate that massive networks of AI-driven “personas” could be deployed. These personas can appear eerily human, complete with generated profile pictures, fabricated personal histories, and a consistent, AI-generated posting history. Propaganda, falsehoods, or divisive rhetoric are thereby amplified with minimal human oversight. These networks leverage AI’s ability to generate high-quality disinformation with extremely low marginal cost and low rates of detection ^[6].

The implications for the discipline of public opinion supervision are profound. Traditional methods of monitoring (such as simple keyword tracking or sentiment analysis) must be augmented with new technical tools capable of network analysis and bot detection. AI-orchestrated influence campaigns must be identified and understood not just as a collection of false posts, but as a systemic manipulation of the discourse architecture. Additionally, students preparing for this field must grasp complex concepts such as algorithmic amplification, the political economy of data, bot detection methodologies, and the difficult ethical dilemmas surrounding counter-disinformation tactics. In summary, a game-changing ability to automate and mass-produce opinion shaping has been introduced by generative AI. This new reality must be a central component of how educators train future communication professionals.

In light of these interconnected challenges, the responsibilities of public opinion supervision are both heightened and fundamentally transformed. It must be ensured by educators that students understand not only the nature of these AIGC-driven threats but also the sociotechnical context behind them. This includes how AI models are trained, how they can be misused, and what legal or technical safeguards exist. The next section outlines a competency framework developed to address these needs. The core skills and literacies needed to effectively supervise public opinion in the era of generative AI are identified.

3. Core Competencies for Public Opinion Supervision in the AIGC Era

To adequately meet the foregoing challenges, students of communications, journalism, and new media must develop a robust and integrated set of competencies. This framework builds upon foundational principles of digital and media literacy but extends them significantly to address the unique affordances of generative AI. A competency framework for the AIGC era is proposed. It consists of four critical and interrelated skill domains: (1) Technical Understanding, (2) Critical Discrimination, (3) Ethical Judgment, and (4) Human–AI Collaboration. These domains were synthesized from and align with recent recommendations from international literature on AI literacy, adapted specifically to the high-stakes context of public opinion supervision. Each competency is defined and rationalized below.

3.1 Technical Understanding of Generative AI

A foundational functional literacy in how generative AI models operate is first needed by students. This is not to suggest that communication students must become computer scientists, but that they must move beyond treating AI as a “black box.” This competency includes knowing the basic principles of machine learning, neural networks, and generative models (e.g., how large language models are trained on vast datasets, and how they produce probabilistic outputs). In the specific context of public opinion, this technical understanding enables students to grasp why AI-generated content can be so convincing. They can learn the technical markers of deepfake algorithms or the “hallucination” tendencies of language models. This understanding also attunes them to the inherent limitations of these systems, such as data biases inherited from training corpora, a fundamental inability to verify factual truth, or a lack of real-world context and common-sense reasoning. For example, a student with this competency should understand that ChatGPT predicts the next most plausible word based on statistical patterns; it does not “know” or “confirm” truth, which is precisely why it may fabricate plausible-sounding

misinformation, complete with fake citations.

Technical know-how also involves a functional familiarity with the ecosystem of tools for detection. This includes an awareness of deepfake forensics, content watermarking, cryptographic origin verification (like C2PA), and AI-output detectors. Crucially, this competency also includes an awareness of the current limitations of these detection tools (e.g., the high false-positive rates of AI text detectors or the ability of adversaries to “fool” detection algorithms). By demystifying how AIGC works “under the hood,” future media professionals can more effectively scrutinize AI-generated materials. They can also better explain to the public or organizational decision-makers why a given piece of content may or may not be trustworthy. This competency corresponds directly to what UNESCO’s framework terms “AI foundations and applications.” In the redesigned course, this was emphasized by teaching the basics of different generative models (GANs, LLMs, Diffusion) and having students conduct hands-on experiments with AI tools to observe and document their behaviors, successes, and failures.

3.2 Critical Discrimination and Analytical Thinking

In an information environment rife with sophisticated AI-generated distortions, students must dramatically hone their ability to critically evaluate information authenticity, quality, and intent. This competency builds directly upon traditional media literacy and critical thinking but places a new and urgent emphasis on detecting AI-specific signs of falsehood and manipulation. It involves a suite of advanced analytical skills. These include traditional methods like verifying sources, cross-checking facts with reliable databases, and using lateral reading strategies to assess the reputation of an information source. However, it also adds new technical heuristics, such as analyzing metadata for signs of manipulation, conducting reverse image searches, and scrutinizing visual or audio content for subtle artifacts (e.g., unnatural blinking, background warping, mismatched audio-video synchronization). Students should learn to ask pointed, hypothesis-driven questions: Does this video exhibit any known artifacts of a specific deepfake generation method? Is this online “persona” posting with superhuman frequency, suggesting automation? Is this quote traceable to a reputable source, or does it have the linguistic hallmarks of being AI-generated? Students must also become adept at recognizing the subtle biases, framing effects, or omissions that AI-generated content might introduce. Generative AI can produce content with a fluent, “human-like” rhetorical style that artfully conceals bias, unreliability, or a lack of source grounding^[7].

Thus, critical discrimination includes developing a mental model of AI systems’ tendencies (e.g., large language models often reflect the dominant biases in their training data or will “confidently” generate incorrect information). Educators should cultivate a “healthy skepticism” in students—a professional reflex to double-check extraordinary claims and to be acutely aware that manipulated or entirely fake content can circulate widely and achieve social validation before verification can occur. Importantly, this competency is not purely technical; it also draws deeply on the social sciences. It requires understanding how misinformation spreads through networks, the psychology of social influence, and the political or economic motives behind coordinated disinformation campaigns. By integrating these technical and social-scientific perspectives, students learn to become true analysts of complex information ecosystems, not just passive consumers or simple fact-checkers.

3.3 Ethical Judgment and Responsibility

The advent of AIGC raises novel and complex ethical questions for those who create, disseminate, or regulate public information. Students must develop a strong, principled sense of ethics and normative judgment regarding AI’s use in communication. This competency is essential for maintaining public trust and mitigating societal harm. It involves a clear understanding of established ethical guidelines (e.g., journalistic principles of honesty, accuracy, transparency, and respect for privacy) and emerging legal standards (e.g., evolving laws on defamation, intellectual property, and data rights) as they pertain to AI-generated content. Students must be prepared to grapple with real-world dilemmas. For example, if a journalist uses ChatGPT to help draft an article, what are the ethical duties to fact-check the AI’s output and to disclose the use of AI assistance to the audience? Or, if a public relations team deploys AI-powered chatbots to engage with social media users during a crisis, how do they ensure these bots do not mislead or deceive the public?

Students should also be guided to grapple with broader, macro-level societal ethics. This includes debates on the appropriate

balance between free expression and harm prevention in the context of deepfakes. It involves analyzing the risk of reinforcing systemic biases (e.g., racial or gender biases) through the uncritical use of AI content. It also includes the critical question of accountability: who is responsible when an AI model disseminates harmful falsehoods—the developer, the user, or the platform?

In our framework, ethical judgment includes both individual ethical usage of AI (micro-ethics) and the ability to contribute to organizational and public governance discussions on AI in media (macro-ethics). This maps to what some pedagogical frameworks call “ethical AI literacy.” Practically, this competency was instilled by presenting students with real-world and hypothetical case-study dilemmas. They were guided through established frameworks of ethical decision-making (e.g., utilitarian, deontological) to analyze the stakes and stakeholders involved. By fostering a principled and reflective mindset, the aim is to produce graduates who can uphold truth and the public interest when they inevitably encounter complex AI-related challenges in their careers.

3.4 Human–AI Collaboration Skills

Finally, beyond simply defending against AI’s risks, students must learn to work effectively, efficiently, and safely with AI tools. This capability transforms AIGC from a perceived threat into a potential “co-worker” or analytical assistant. This represents a form of “AI fluency” that will be a critical workplace skill.

In the public opinion supervision context, this means knowing how to strategically leverage AI for appropriate tasks. These might include content analysis (e.g., using an LLM to perform thematic analysis on thousands of social media comments), data mining (e.g., identifying emerging narratives), language translation, drafting initial reports, or generating creative multimedia for public service announcements. The key, however, is maintaining rigorous human oversight, editorial judgment, and ultimate accountability. The notion of human-AI collaboration includes a set of practical skills. “Prompt engineering”—the ability to formulate clear, effective, and nuanced queries to elicit desired outputs from AI systems—is paramount. So is the skill of critically evaluating AI outputs, rather than passively accepting them at face value. This involves integrating AI assistance into professional workflows in a manner that is both transparent and accountable^[8].

Students should be trained to recognize where AI can provide a significant advantage—e.g., using natural language generation to summarize large volumes of data quickly—but also, critically, where human expertise is irreplaceable. This includes tasks requiring deep contextual understanding, nuanced cultural interpretation, subjective judgment, and ethical discernment. Developing this competency prepares students for a workplace that increasingly expects proficiency with a wide array of AI tools. It also aligns with calls for a new “rhetorical literacy” in the age of AI—i.e., the skill of using AI-generated language strategically and responsibly to achieve communication goals. In our teaching, human-AI collaboration was incorporated by assigning project work where students were required to use generative AI as a creative aid or research assistant, and then critically evaluate its contributions in a meta-reflective report.

In summary, this comprehensive competency framework for the AIGC era spans technical, critical, ethical, and collaborative skill sets. These domains are designed to be mutually reinforcing: technical knowledge aids critical analysis; ethical principles must guide the use of technical tools; and human-AI collaboration can only flourish when it is underpinned by rigorous critical oversight and high ethical standards.

4. Teaching Innovations in “Online Communication and Public Opinion Supervision”

LeBron To translate the four-domain competency framework from theory into practice, the course “Online Communication and Public Opinion Supervision” underwent a significant pedagogical redesign. A traditional lecture-and-exam format was deemed insufficient. It was replaced with a blended, active-learning model. A variety of teaching innovations were introduced, combining foundational theoretical learning with intensive, hands-on practice. The key innovations are detailed below.

4.1 Curriculum Update - AIGC and Public Opinion Module

The most fundamental innovation was the introduction of a dedicated, multi-week module on “Generative AI in the Information Ecosystem.” This module was strategically placed early in the semester to provide foundational context for all subsequent activities. This module was explicitly interdisciplinary, bridging communication theory with basic computer science concepts.

The module delivery included:

Technical Primers: Lectures were designed to demystify AIGC. They covered the basic principles of generative models (e.g., Generative Adversarial Networks for images, transformers for language), the role of training data, and the concept of probabilistic generation. This was crucial for building the “Technical Understanding” competency.

Real-World Case Studies: The module was heavily case-driven. Students were required to analyze recent, high-profile incidents where AIGC had a measurable impact on public opinion. Both international and domestic cases were examined, for example, AI-generated fake images of political events, domestic viral rumors traced to AI-generated audio, and the “Pentagon explosion” fake image incident. For each case, students analyzed the full lifecycle: the content’s creation, its amplification vectors (e.g., social media algorithms, influential accounts), the public’s reaction, and the subsequent debunking and verification efforts.

Countermeasure Landscape: Embedding such up-to-date cases made the learning authentic and urgent. To avoid a purely dystopian framing, this module also covered the landscape of emerging countermeasures. This included discussions on deepfake detection technologies (and their limitations), digital content authentication standards (like C2PA), and regulatory policies from different national contexts (e.g., China, EU, US).

This foundational knowledge, covering the threat, the technology, and the response, fed directly into the subsequent practical and simulation-based activities.

4.2 “Red Team vs. Blue Team” Simulation Exercises

To move from passive knowledge to active skill, inspiration was drawn from cybersecurity training and professional wargaming. Multi-day simulation exercises were implemented where the class was split into opposing teams to role-play a live information contest. This pedagogy mirrors the concept of treating disinformation as an adversarial, dynamic conflict.

The simulation was structured in three phases:

Phase 1: Preparation. The class was divided into a “Red Team” (attackers) and a “Blue Team” (defenders). The Red Team’s objective was to create and strategically disseminate a piece of AI-generated disinformation on a pre-approved, low-stakes topic (e.g., a fabricated campus policy, a false local event). They were required to use publicly available AI tools. The Blue Team’s objective was to establish a “public opinion monitoring center” and develop a protocol for detecting and responding to falsehoods.

Phase 2: Execution. Over a 48-hour period, the Red Team “released” its content into a closed digital environment (e.g., a private class forum or social media group). The Blue Team was tasked with actively monitoring these channels, aiming to be the first to detect the fake, verify its falsehood, issue a “public clarification,” and trace its origin.

Phase 3: Debrief. This was the most critical phase. A mandatory, two-hour reflective debrief session was held. Students stepped out of their roles and presented their strategies. The Red Team detailed their creation process and dissemination tactics. The Blue Team presented their detection workflow, including any false positives or misses.

Such “red vs. blue” scenarios created a competitive yet highly educational dynamic. Students on the Red Team gained visceral insight into how easily and quickly convincing false content can be produced. Students on the Blue Team practiced critical analysis and crisis response under time pressure. This single exercise powerfully reinforced technical skills (using AI, using detection tools) and critical skills (spotting fakes). It also surfaced complex ethical discussions. Many Red Team members reported feeling “uneasy” or “guilty” about crafting convincing lies, which led to a profound class conversation on the ethics of information warfare and the responsibilities of communicators. The simulation proved to be a high-impact pedagogy, making abstract threats concrete and memorable.

4.3 Project-Based Assignments with AI Integration

To foster the “Human–AI Collaboration” competency, several major course assignments were redesigned to require the ethical and critical integration of AI tools. This was structured within a project-based learning (PBL) format. One major project was an “AI-Augmented Media Analysis Report.” Student teams selected a recent, real-world public opinion event (e.g., a corporate PR crisis, a viral social movement). Their task was to write an analytical report, but they were mandated to use generative AI tools to assist in at least two phases of their research. For instance, they might prompt a chatbot to:

Summarize hundreds of social media comments to identify key themes.

Draft an initial literature review on the topic.

Analyze a set of images for signs of manipulation.

Generate code for a simple data visualization.

The crucial part of the assignment was not the final report itself, but a mandatory 2-page “AI Collaboration Appendix.” In this appendix, students had to document every prompt they used, the raw output the AI provided, and a critical evaluation of that output. They had to “grade” the AI’s contribution, identify any inaccuracies or biases it introduced, and describe how they corrected or refined its work. The AI, in essence, became a “team member” subject to human supervision and performance review. Another assignment had students create a public service announcement (PSA) on digital literacy in the AI era. They were encouraged to use text generation tools to brainstorm scripts or slogans and image generation tools for visuals. However, they were graded on how well they curated, edited, and fact-checked the AI outputs to align with factual correctness, ethical guidelines, and an appropriate public-service tone. This project-based use of AI kept engagement high. It moved students from theoretical awareness of AI to practical, hands-on fluency, ensuring they learned with AI in a critical and meaningful way.

4.4 Oral “Deepfake Crisis” Response Drills

Public opinion supervision and crisis communication often involve high-pressure, real-time decision-making. To build competency in such scenarios, the course introduced a series of oral crisis response drills. These were, in effect, simulations of a press briefing or internal executive Q&A in the immediate aftermath of a viral AI-driven rumor or deepfake. A typical drill scenario was presented as follows: “It is 8:00 AM. Overnight, a deepfake video of your organization’s CEO making discriminatory remarks has gone viral on all major platforms. The media is calling, and employees are panicking. As the head of communications, you must deliver an impromptu 3-minute statement to the press and then answer 5 minutes of tough questions.”

Students took turns in the “hot seat” at the front of the class, role-playing as the spokesperson. Their classmates role-played as aggressive journalists or concerned citizens, asking difficult questions. Students had minimal time to prepare, mirroring the reality of how fast-breaking digital crises unfold.

These drills served multiple educational purposes:

Cognitive: They forced students to synthesize information quickly (What do we know? What can we not say? What is the core message?). This reinforced critical discrimination skills under severe time constraints.

Performative: They provided practice in strategic crisis communication—learning to calmly convey facts, authoritatively refute the fake without over-amplifying it, and pivot to messages of public trust and procedural integrity.

Procedural: The exercise highlighted the absolute importance of preparation and protocols. Students quickly realized the value of having pre-established crisis response plans specifically for dealing with AI-driven forgeries, echoing emerging industry best practices.

Feedback indicated these drills were initially intimidating but ultimately the most confidence-building part of the course. They viscerally connected theory (e.g., “deepfake threats”) to practice (e.g., “What do I do?”). Collectively, these four innovations—the updated module, the adversarial simulation, the AI-integrated projects, and the live crisis drills—restructured the course into an active, experiential learning environment explicitly geared towards the challenges of the AIGC era.

5. Empirical Outcomes: Classroom Observations and Student Feedback

Player To To gauge the effectiveness of these pedagogical innovations, a mixed-methods approach was used. Data were collected throughout the semester, including observational data during exercises, analysis of final project quality, and formal qualitative feedback from students via end-of-term surveys and reflective essays. Although this case study was not a controlled experimental study, the before-and-after comparisons (against previous iterations of the course) and the richness of the qualitative insights provide strong evidence of notable improvements in student competencies and engagement. The key findings from the case implementation are summarized below.

5.1 Enhanced Analytical Performance and AI Literacy

By the conclusion of the course, students demonstrated a marked and measurable improvement in their ability to identify, analyze, and deconstruct AI-generated content. One key metric came from a practical final exam. Students were given a “dossier” containing a set of mixed-media news items (a mix of genuine news articles, AI-fabricated articles, a lightly edited deepfake image, and an AI-generated audio clip). They were tasked to determine which items were suspect and provide a detailed justification for their reasoning.

In the initial weeks, a similar diagnostic quiz showed low accuracy; students primarily relied on “gut feeling.” On the final exam, a substantial gain in critical discrimination skills was evident. A large majority of students correctly identified the deepfake image and the AI-generated news story. More importantly, their justifications were no longer vague. They used specific terminology learned in the course, citing “unnatural linguistic patterns and lack of verifiable sources” for the AI text, and “background warping and unnatural eye movement” for the deepfake.

Observationally, during the “Red vs. Blue Team” simulations, the Blue Teams became progressively more adept at using systematic verification tools and cross-referencing information. This demonstrated an internalization of the “critical discrimination” competency. Furthermore, in an AI literacy survey administered at the semester’s end, a large majority of students agreed with the statement “I understand how generative AI produces content and its potential inaccuracies,” a significant increase from the start of the semester. This outcome supports the hypothesis that active, problem-based learning interventions can significantly boost functional and critical AI literacy among communication students ^[9].

5.2 Growth in Ethical Reasoning and Judgment

Another significant observed change was in the sophistication and nuance of students’ discussions surrounding media ethics. In final reflective essays, many students described a fundamental transformation in how they view their future role as media professionals. Initially, some expressed a narrow, technical view of public opinion work (e.g., “posting news quickly”). By the course end, there was a widespread and articulated acknowledgement of a profound duty to verify information, consider societal impact, and act as a guardian of public trust before disseminating content. This reflects a clear ethical maturation. During in-class debates on hypothetical policies (e.g., “Should all AI-generated content be legally required to carry a watermark?”), students engaged with complex nuances. They moved beyond simple “yes” or “no” answers to weigh concepts like free speech against harm prevention, demonstrating familiarity with ideas like the “liar’s dividend” and the importance of maintaining public trust.

One student’s reflection was particularly telling: “I realize now that rushing to break a story that might be a deepfake could do real damage, even if it brings clicks. As communicators, we must act as guardians of truth, even if that means delaying publication until verification is complete.” This statement reflects a deep internalization of the “ethical judgment” principles. It is noteworthy that students who served on the “Red Teams” (and actively created fake content) had some of the most poignant ethical reflections. They often noted how uncomfortably easy it was to fool their peers and thus how great the responsibility is to combat such deception. These insights suggest that the course’s experiential methods effectively sensitized students to the high ethical stakes of AIGC.

5.3 Increased Engagement and Confidence (Affective Outcomes)

The introduction of interactive, relevant, and challenging activities had a highly positive and measurable effect on student engagement. Class attendance and participation in discussions were significantly higher than in previous, lecture-based offerings of the course. The “Red vs. Blue” team games, in particular, injected a palpable energy into the classroom. Students who were usually quiet in traditional lectures became highly involved in strategizing, sleuthing, and debating during the simulations. In end-of-term feedback surveys, the course was rated as “highly engaging” by a significant majority of students. They frequently mentioned that the “realism” and “novelty” of the tasks (e.g., tackling deepfakes, using cutting-edge AI tools) made them eager to come to class and participate. Many commented that the simulations and drills were “challenging but fun” and that they appreciated the chance to apply theory to “feel like a real investigator or spokesperson.”

This engagement is valuable because research has shown that students who feel involved and interested tend to achieve deeper learning outcomes. Additionally, student confidence—or self-efficacy—improved dramatically. In the initial class,

a majority reported feeling “unprepared” or “very unprepared” to deal with AI in their future jobs. By the final class, a vast majority of students stated they felt “prepared” or “very prepared” to handle scenarios involving AI-generated content. This boost in self-efficacy is a critical affective outcome. One student noted that after successfully writing a press release to debunk a fake video in a drill, she felt “much more confident that I could do this in a real job.” Another said the course changed their mindset from fearing AI as a job-destroying threat to viewing it as “an issue I know how to manage—and even a tool I can use.”

5.4 Feedback on Specific Pedagogical Methods

Qualitative feedback from students underscored which innovations they found most effective.

The “Red Team vs. Blue Team” simulations received nearly unanimous enthusiastic praise. Students felt these exercises gave them “practical skills in a memorable way” that a lecture never could. The “AI-Augmented Project” also received positive remarks. Students stated it taught them how to use tools like ChatGPT productively (e.g., for brainstorming or summarizing) while also—and more importantly—teaching them not to trust the tool blindly. Several admitted that in their first attempts, they leaned too heavily on the AI and their analysis was shallow; the requirement to “show their work” in the appendix forced them to become more critical ^[10].

The “Crisis Response Drills” were consistently cited as the most “challenging” or “nerve-wracking” component, but many acknowledged that this was precisely why it was valuable. They learned the importance of preparation and “thinking on your feet.” One constructive critique received was to incorporate more collaborative oral drills, so students could work as a team to handle a crisis, rather than always being in the “hot seat” alone. This is a suggestion being considered for future iterations.

6. Discussion and Limitations

The aggregate empirical outcomes from this case study are highly encouraging. Students demonstrated objective improvements in skill (analysis accuracy) and subjective growth in confidence, engagement, and ethical awareness. These findings support broader educational claims that innovative, experiential, and problem-based pedagogies are particularly effective for teaching complex socio-technical topics. By simulating the pressures and complexities of real-world public opinion supervision in the AI age, the course helped students build both the “cognitive muscle memory” and the reflective “ethical mindset” needed to act competently and responsibly.

The success of the “Red Team vs. Blue Team” model, in particular, suggests that adversarial learning can be a powerful tool for media education, just as it is in cybersecurity. It forces students to move beyond a passive “receiver” role and become an active participant in the information contest, leading to deeper, more lasting understanding. The “Human-AI Collaboration” projects also proved effective, striking a balance between embracing new tools and instilling critical oversight. This addresses a key anxiety for many students: how to use AI without “cheating” or becoming over-reliant. By making the use of AI explicit, mandatory, and reflective, the course normalized it as a professional tool that, like any tool, requires skill and ethics to wield.

However, the limitations of this study must be acknowledged ^[11].

Scope and Scale: The findings are from a single case study, implemented in one course with a relatively small cohort (approximately 30 students). The results may not be generalizable to all university contexts, student populations, or different course subjects.

Methodology: The “empirical” data rely heavily on self-reported feedback, instructor observation, and qualitative analysis rather than rigorous, quantitative experimental evaluation. There was no control group (e.g., a class taking a traditional lecture-based version of the course) for direct comparison.

Long-Term Retention: This study measured outcomes at the end of the semester. It did not (and could not) track the long-term retention of these skills or how students will apply them in their professional careers ^[12].

Rapidly Evolving Tech: The course was designed around AIGC tools and threats from 2023-2024. The technology is evolving at an exponential rate. The specific technical skills taught (e.g., how to spot a certain type of artifact) may become obsolete quickly.

Future work is needed to address these limitations. More formal assessment (e.g., pre/post standardized tests of AI literacy)

and comparative studies with control groups would strengthen the evidence base. Nonetheless, as a practical, pedagogical exploration, this case study offers tangible and useful insights for educators seeking to modernize their teaching approaches in a rapidly changing world.

Conclusion and Future Directions

The rapid, disruptive rise of generative AI is fundamentally reshaping the landscape of public communication. It poses new and profound challenges to the supervision of public opinion, the integrity of information, and the stability of public trust. This paper examined those challenges and presented a detailed case study of pedagogical innovation designed in response. Core competencies for media professionals in the AIGC era were identified: technical understanding, critical discrimination, ethical judgment, and human-AI collaboration^[13].

To foster these competencies, the course “Online Communication and Public Opinion Supervision” was comprehensively redesigned. The new curriculum featured a mix of theoretical updates and high-impact experiential learning activities, including modules on AI and misinformation, “red/blue team” disinformation wargames, AI-augmented project-based learning, and simulated crisis response drills. The reported outcomes, based on observational and qualitative data, show that such interventions can significantly improve students’ analytical skills, AI literacy, ethical awareness, and professional confidence. Students left the course better equipped to distinguish truth from sophisticated fabrication, to use powerful AI tools judiciously, and to act as responsible, ethical stewards of the information ecosystem.

Several key insights emerge from this case study for educators in related fields.

Active Learning is Essential: Simply warning students about deepfakes in a lecture is insufficient. Engaging them in the process of creating and debunking fake content, as in the adversarial simulation, proved far more impactful. This aligns with constructivist learning theory.

Integrate Ethics Everywhere: Ethics cannot be relegated to a single “Week 10: Ethics” module. In our course, every hands-on activity was paired with a mandatory ethical debrief, helping students connect technical actions with moral principles.

Embrace, Don’t Ban, AI Tools: The “AI-Augmented Project” model provides a framework for teaching with AI, rather than attempting to ban it. It cultivates the critical collaboration skills that employers will demand.

Agility is Key: The success of the course was partly due to its timeliness. This suggests that faculty development and curriculum design processes need to become more agile to keep pace with technological change.

Looking ahead, several future directions can be pursued. From a teaching perspective, the interdisciplinary scope of such courses could be expanded. Collaborative modules involving computer science students (demonstrating algorithm design) and communication students (analyzing impact) could be mutually enriching. International case comparisons, analyzing how different media ecosystems and regulatory environments (e.g., China, EU, US) are responding to AIGC, can broaden students’ global perspectives.

In terms of research, this pedagogical case study could be extended with more rigorous assessment. Researchers could formally measure how much a simulation improves detection skills versus a control lecture, or track the long-term retention of these skills into graduates’ careers. There is also room to investigate the affective dimension further: how do exercises dealing with AI-driven deception affect student attitudes like cynicism or vigilance months later?

In conclusion, generative AI undeniably poses serious challenges to the authenticity and management of public opinion. But with thoughtful curriculum design and a steadfast commitment to competency-based, experiential education, we can prepare the next generation of professionals to meet these challenges. The experience from this course demonstrates that students, when given the right tools, training, and learning opportunities, can indeed rise to the occasion. They can become savvy analysts, ethical communicators, and innovative collaborators, qualities that will be indispensable for safeguarding the information ecosystem.

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AI Literacy in Vocational Education: A Framework for Teacher Professional Development

Yuchu Shi^{1*}, Mingming Gu², Mingming Li³

1. Anhui Business and Technology College, Hefei, 230000, China

2. Hefei Gongda Vocational and Technical College, Hefei, 230000, China

3. Hefei Preschool Education College, Hefei, 230000, China

*Corresponding author: Yuchu Shi, 15256705599@163.com

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Abstract: The application of artificial intelligence in education prompts an evolution in the professional competencies required of teachers. Current discussions on teacher AI literacy are predominantly situated within the context of general education, failing to capture the unique characteristics of vocational education, such as industry-education integration and school-enterprise collaboration. Consequently, a specific framework for vocational college teachers is absent, and existing research has not addressed this need. This study, grounded in empowerment theory, constructs an AI literacy framework for vocational college teachers. It elaborates on the competency dimensions related to human-computer collaboration, including the use of AI to understand industry demands, design instructional scenarios, and align curriculum with workplace requirements. The research further analyzes the practical constraints on literacy enhancement from the perspectives of policy environments, institutional support mechanisms, and teacher cognition, proposing corresponding developmental pathways. This study aims to provide a theoretical reference and practical guidance for the professional development of educators in the vocational sector.

Keywords: Artificial Intelligence Literacy; Vocational College Teachers; Human-Computer Collaboration; Industry-Education Integration

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1. Introduction

The advancement of artificial intelligence is reshaping the educational ecosystem, influencing pedagogical practices and teacher roles ^[1]. Teacher artificial intelligence (AI) literacy is consequently regarded as a key competency supporting the digital transformation of education ^[2]. Existing research on teacher AI literacy frameworks has predominantly centered on general education, without adequately addressing the specific requirements of the vocational education context ^[3]. Vocational education, oriented toward industry-education integration, requires that teacher AI literacy extend beyond general technological application skills to encompass practical dimensions such as industry data analysis, the integration of authentic projects, and the dynamic adjustment of talent development programs ^[4]. Teachers in vocational colleges currently face multiple challenges in developing their AI literacy. These challenges include insufficient policy and resource support ^[5], weak school-based collaborative mechanisms ^[6], and inadequate cognitive and skill preparedness among educators ^[7]. These factors collectively constrain the effective implementation of AI within vocational education.

This study therefore constructs an AI literacy framework tailored for vocational college teachers and explores its developmental pathways. It addresses the following core questions: What dimensions should this literacy encompass? What practical dilemmas impede its advancement? Through what mechanisms can its cultivation be effectively supported? The investigation of these questions is intended to provide a theoretical reference and practical framework for teacher professional development in the age of artificial intelligence.

2. Constructing the Teacher AI Literacy Framework

2.1 The Human-Computer Collaborative Relationship from the Perspective of Empowerment Theory

The conceptual foundation for a teacher AI literacy framework rests upon an examination of the relationship between educators and technology in the age of artificial intelligence. This study moves beyond both the pessimistic narrative of “technological replacement” and the uncritical optimism of “technological solutionism.” It is instead grounded in empowerment theory, which frames artificial intelligence as a tool for enhancing the professional capabilities of teachers. The core of this perspective is the establishment of a new human-computer collaborative relationship, wherein the dynamic between a teacher and AI is not one of control and subordination but rather a complementary and symbiotic partnership^[8].

Artificial intelligence is not intended to replace the charisma, emotional insight, and creative thinking inherent to educators. On the contrary, by assuming responsibilities such as knowledge retrieval, data analysis, and routine task processing, AI can free teachers from cumbersome administrative work. This enables them to focus on core professional activities like instructional design, personalized guidance, and substantive teacher-student interactions^[9]. In this synergistic relationship, the teacher acts as the agent guiding the technology, while AI functions as the medium through which their pedagogical wisdom and effectiveness are extended. The two components form an integrated system, with the ultimate objective of fostering the holistic and personalized development of students^[10].

2.2 Definition and Core Framework of Teacher AI Literacy

Based on the aforementioned empowerment perspective of human-computer collaboration, the concept of teacher AI literacy extends beyond the simple operation of technology. It is defined as a comprehensive system of competencies that enables teachers to work effectively, critically, and ethically within an AI-driven educational environment^[3]. A consensus in international scholarship suggests that AI literacy should encompass multiple dimensions, from knowledge comprehension to ethical judgment^[11]. Integrating established theoretical models, such as the AI literacy competency framework proposed by Long and Magerko (2020) and Chiu’s (2021) perspectives on sustainable AI curriculum planning, while specifically addressing the “vocational” and “practical” characteristics of vocational education, this study constructs a core AI literacy framework for vocational college teachers that comprises five dimensions:

(1) AI Cognition and Attitude

A teacher’s cognition and attitude toward artificial intelligence form the internal motivation for their application of AI technologies. This dimension requires educators to understand not only the basic concepts of artificial intelligence but also its potential applications and inherent limitations within the educational domain^[12]. Building on this understanding, teachers are expected to cultivate an orientation that is both open and prudent, balancing the active acceptance of technological empowerment with a critical awareness of AI systems and their effects^[13]. This combination of cognition and attitude lays the groundwork for continuous learning and the effective application of AI in professional practice.

(2) AI Knowledge and Skills

This dimension pertains to the teacher’s capacity to operate and apply artificial intelligence tools in practical instructional settings, a prerequisite for effective human-computer collaboration. Educators should be familiar with the core functions of common AI educational tools (e.g., intelligent tutoring platforms, generative AI systems) and master practical skills such as prompt optimization, interpretation of output, and preliminary data analysis^[14]. These competencies directly determine a teacher’s ability to integrate AI technology effectively into instructional design, classroom interaction, and learning assessment.

(3) AI Pedagogical Application and Innovation

Reflecting the practice-oriented nature of teacher AI literacy, this dimension focuses on the ability to translate AI-related

knowledge into actual teaching behaviors. Teachers are expected to systematically integrate artificial intelligence tools into key pedagogical stages, including instructional design, scenario creation, skills training, and formative assessment ^[15]. This capability should then evolve into pedagogical innovation, where educators leverage AI tools to creatively solve practical problems within their specific disciplines or professions, thereby promoting the optimization of teaching strategies and models.

(4) AI Ethics and Security

This dimension provides the ethical foundation for the appropriate and compliant use of artificial intelligence. Teachers should be able to identify and address critical ethical issues such as data privacy protection, algorithmic transparency, fairness in decision-making, and technological reliability ^[16]. In their practice, educators are responsible for guiding students toward a critical understanding of AI technology. They must consistently adhere to student-centered educational principles in human-computer collaboration ^[1], ensuring that the application of AI aligns with educational ethics and social responsibility.

(5) Empowerment through Industry-Education Integration

This dimension embodies the distinctive characteristics of AI literacy for vocational college teachers, emphasizing their role in aligning education with industry. Teachers are required to utilize artificial intelligence to analyze industry dynamics and shifting skill demands, while integrating authentic enterprise projects and practical scenarios into the instructional process ^[17]. This capability extends to the collaborative development and dynamic optimization of talent development programs. By leveraging AI tools, teachers can achieve a precise alignment between curriculum content and job requirements, thereby enhancing the industry adaptability of the graduates.

3. Practical Dilemmas in Enhancing AI Literacy for Vocational College Teachers

3.1 Issues in Policy Support and Resource Allocation

At the macro level, inadequacies in policy guidance and resource allocation constrain the effectiveness of system-wide implementation.

Absence of policy and standards. A standard framework for teacher AI literacy at the national or industry level is largely absent within the vocational education sector ^[4]. This absence results in ambiguous objectives for teacher training and insufficient criteria for assessment, leading to fragmented practical explorations across different locales. While scholars have called for the development of specific guidelines, a binding and directive top-level design has not been established. Consequently, policies that link AI literacy to incentive systems, such as professional title evaluations, are difficult to implement effectively.

Structural disparities in resource investment. Disparities exist in the allocation of AI infrastructure and dedicated funding across regions and institutions ^[18]. For instance, vocational colleges in economically developed regions have greater access to opportunities for collaborating with enterprises to establish “AI training labs,” whereas institutions in remote areas may lack the conditions needed to access fundamental AI tools ^[19]. This uneven distribution of resources places educators in certain institutions at a disadvantage from the outset.

3.2 Limitations in Institutional Support and Collaborative Mechanisms

At the institutional level, the insufficient efficacy of support systems is a key factor impeding the implementation of policy.

Disconnect between school-based training and practice. Existing institutional training often remains generalized, concentrating on the operation of generic tools without adequate integration into the instructional contexts of specific vocational fields, such as CNC machining, elder care, and culinary arts ^[20]. Such a training model is ill-equipped to address the concrete problems teachers face in their practice, indicating an absence of mechanisms driven by authentic problems.

Insufficient collaborative innovation among industry, academia, and research. The characteristic of industry-education integration in vocational education has not been sufficiently manifested in AI pedagogical applications. Collaboration between institutions, enterprises, and research organizations often remains at a superficial level; technology platforms provided by companies may be incompatible with the curriculum, and educators rarely participate in the early design of these products, which results in a misalignment between the tools and pedagogical requirements.

Absence of evaluation and incentive mechanisms. Current systems for teacher performance appraisal and professional title

review generally fail to incorporate AI literacy and its associated pedagogical innovations as key metrics^[21]. When the efforts made by educators in this area do not receive institutional recognition, their intrinsic motivation can be undermined.

3.3 Individual Teacher Cognition and Practical Constraints

At the individual teacher level, barriers arise from the interplay of internal cognitive and affective factors with external practical conditions.

Concerns over agency and technological anxiety. Teachers exhibit complex attitudes toward AI. Some educators fear that an over-reliance on technology may diminish their pedagogical agency, reducing them to executors of algorithms. Others experience anxiety and resistance due to a lack of familiarity with the technology^[22]. This apprehension that the role of technology might supersede the core tenets of education, coupled with uncertainty about their professional roles in this new environment, constitutes a profound psychological barrier.

Time and energy constraints. Vocational college teachers typically manage heavy workloads, encompassing teaching, practical training supervision, and administrative duties, which leaves them with limited discretionary time for systematically learning new technologies and engaging in pedagogical innovation^[23]. In the absence of measures to alleviate these responsibilities, the imperative to enhance AI literacy can be perceived as an additional burden.

Differences in adaptability and cognitive inertia. A teacher's age and prior experience correlate with their level of AI literacy. Some older educators or those from non-technical disciplines may adapt to new technologies at a slower pace^[24]. Without targeted support, these teachers may be more inclined to adhere to familiar pedagogical models.

4. Strategies for Enhancing the AI Literacy of Vocational College Teachers

The cultivation and advancement of teacher AI literacy necessitate a systematic approach characterized by multi-level coordination. Grounded in a tripartite framework involving government, institutions, and educators, the enhancement of literacy for vocational college teachers should integrate the distinctive features of vocational education. This requires a mechanism that organically links macro-level guidance, meso-level support, and micro-level practice.

4.1 The Governmental Level

The government should exercise its macro-regulatory function to construct a standard system and policy environment for teacher AI literacy that aligns with the developmental needs of vocational education in the age of artificial intelligence. In terms of standard-setting, drawing on the experience of developing the Competency Standards for Primary and Secondary School AI Teachers, a collaborative effort involving vocational education steering committees, industry enterprises, and research institutions should be undertaken to formulate Developmental Guidelines for the AI Literacy of Vocational College Teachers. These guidelines ought to highlight the unique characteristics of vocational education, encompassing dimensions such as AI cognition, technological integration, pedagogical innovation, and ethical security. They should also specify the core competency requirements for teachers in different professional categories regarding AI application, thereby providing a basis for teacher training and evaluation^[25]. To enhance the scientific validity and applicability of these standards, the development process should involve broad participation from stakeholders, including vocational college teachers, corporate technology experts, and students.

Ensuring effective implementation requires the establishment of inter-departmental coordination mechanisms, coupled with increased financial investment and resource allocation. To mitigate regional and institutional disparities, dedicated support funds should be established for vocational colleges in less developed areas, such as the central and western regions and rural locales. This includes constructing regional, shared "AI training bases" to facilitate the joint development and sharing of quality curriculum resources, technological tools, and practical case studies^[22]. Concurrently, participation in the formulation of and collaboration on international standards in artificial intelligence should be encouraged to align domestic literacy standards with global benchmarks, enhancing the openness and modernization of vocational education.

4.2 The Institutional Level

As pivotal actors bridging policy with practice, institutions should integrate internal and external resources to construct an AI literacy development ecosystem that is centered on practice and organized by professional disciplines. Guided by the concept of "core practices," institutions should move beyond traditional, unidirectional training models to design modular, workshop-

style, school-based training content centered on authentic instructional scenarios ^[26]. For instance, training for equipment manufacturing disciplines could focus on AI applications such as intelligent fault diagnosis and virtual simulation. In contrast, for modern service-oriented professions, the emphasis would be on the pedagogical integration of AI for customer data analysis and personalized service recommendations. This approach reinforces the capacity of teachers to translate AI tools into pedagogical practice through “learning by doing.”

In terms of support mechanisms, institutions should actively collaborate with research organizations, universities, and AI enterprises to establish a multi-party collaborative network involving government, institutional, industry, and corporate partners. AI-focused professional learning communities for teachers can be fostered by organizing their participation in industry practices, co-developing instructional resources, and conducting interdisciplinary research activities. Institutions with available resources can establish “AI pedagogical innovation studios.” These studios, led by key teachers, would focus on overcoming challenges in technological integration within specific disciplines and foster a developmental atmosphere of mentorship and mutual support.

4.3 The Teacher Level

As the primary agents of their literacy enhancement, teachers must proactively expand their cognitive boundaries and construct, through practice, pedagogical concepts and competency structures appropriate for the age of artificial intelligence. On a cognitive level, educators should maintain awareness of AI policy directives and technological frontiers. By engaging with industry reports and participating in professional development, they can systematically grasp the developmental trends and potential impacts of AI in education. It is necessary to cultivate an educational philosophy of “human-computer collaboration,” viewing artificial intelligence rationally as a supportive instructional tool and avoiding the cognitive pitfalls of “technological solutionism” or “technological rejection.”

On a practical level, the emphasis should be on enhancing the capacity to integrate AI technology with professional instruction. Referencing AI empowerment frameworks across areas such as teaching, learning, management, assessment, and decision-making, teachers can embed intelligent lesson-planning tools into instructional design, utilize AI for group optimization and interaction control during classroom activities, and introduce data-driven formative assessments for student evaluation ^[19]. Furthermore, educators should actively conduct action research based on authentic problems. Through a cyclical process of design, practice, reflection, and improvement, they can continuously optimize the pedagogical suitability and effectiveness of artificial intelligence tools.

5. Conclusion and Future Research

The UNESCO Beijing Consensus on Artificial Intelligence and Education calls for the cultivation of teacher digital competency to advance the digitalization of education. Against the backdrop of rapidly advancing AI technology, the question of how to empower teacher professional development has become a key issue for education systems globally. This study presents a preliminary exploration of this theme, constructing a framework for teacher AI literacy and proposing an implementation pathway that coordinates macro, meso, and micro levels to foster its development.

However, the research is subject to limitations. The proposed literacy framework is detailed only to second-level indicators, and an operational third-level indicator system has not been developed. Future inquiry could proceed in two directions. One line of research could focus on conducting more targeted AI literacy studies for teachers within specific professional disciplines. Another could involve developing a third-level indicator system and undertaking empirical research to further refine the framework. Such efforts would contribute to the formulation of more directive and practical strategies for enhancing teacher AI literacy.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Scenario-Driven Scriptwriting Pedagogy: A Design Framework for Practice-Oriented Film Production Education

Jin Tang*

Greater Bay Area Film and Television School, Zhujiang College, South China Agricultural University, Guangzhou, 510900, China

**Corresponding Author: Jin Tang*

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Abstract: In contemporary higher education, particularly within practice-oriented film production programs—such as cinematography, directing, and screen production—scriptwriting courses grapple with a persistent and fundamental challenge: a systemic disconnection between theoretical knowledge and practical, executable application. Students often achieve proficiency in reciting narrative theories, such as the Three-Act Structure or the Hero’s Journey, yet consistently fail to translate this abstract knowledge into the creation of visually compelling, budget-conscious, and production-ready screenplays. To effectively address this critical pedagogical gap, this paper proposes and constructs a novel instructional design model: the Scenario-Driven Pedagogy (SDP) for scriptwriting instruction. The aim of this design study is not to report empirical findings, but rather to articulate a robust theoretical framework and detailed implementation blueprint. The SDP model rigorously integrates the key principles of three foundational educational theories: Constructivism, Situated Learning Theory, and Experiential Learning. The core innovation of SDP lies in its mandate to embed all writing tasks within highly authentic, constrained, and collaborative production scenarios, thereby compelling students to adopt the cognitive and professional identity of a filmmaker first, rather than a mere writer. This paper meticulously elaborates the four guiding principles that govern the SDP framework—authenticity, integration, iteration, and scaffolding—and presents a comprehensive typology of three distinct scenario designs (Constraint-Based, Role-Based, and Visual-Prompt). Furthermore, it outlines a four-phase implementation blueprint adaptable to semester-long curricula. It is argued that SDP offers a rigorous, transformative pedagogical approach capable of effectively bridging the gap between abstract narrative theory and concrete production practice, establishing a solid foundation for cultivating professional film students equipped with both acute narrative competence and essential visual and logistical production literacy.

Keywords: Scriptwriting Pedagogy; Scenario-Driven Learning; Film Production; Instructional Design; Experiential Learning

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1.Introduction

1.1 The Persistent Divide Between Theory and Practice

Modern film and media programs are inherently vocational, designed to equip graduates with the skills necessary to navigate the collaborative and complex landscape of professional film production. Central to this enterprise is scriptwriting, the foundational discipline where cinematic concepts are first given form. Yet, across numerous curricula, the teaching of screenwriting often remains an isolated and problematic domain. The dominant pedagogical models currently in use—often

inherited from literary studies—tend to focus on two distinct, yet equally insufficient, approaches: the Classic-Analytic Mode (focused on deconstructing established film narratives) and the Rule-Application Mode (focused on strict adherence to structural paradigms like Syd Field's paradigm or Robert McKee's principles). While these models provide necessary narrative vocabulary, they inadvertently cultivate a form of "disembodied knowledge." Students understand what a conflict is, but not how to write a conflict that is dramatically visualizable and logistically feasible to shoot. The Rule-Application Mode, in particular, can lead to formulaic, emotionally sterile scripts that fulfill a checklist of plot points without achieving genuine narrative resonance (Smith, 2022). The resulting student screenplays frequently betray this theoretical bias: they are verbose, overly reliant on internal monologue or psychological description, and often oblivious to the practical realities of budget, location, and camera placement. The output is, essentially, "unproduceable prose" masked as a script. This disconnect represents a significant failure to prepare students for the industry, where a successful screenplay is not merely a literary artifact but a detailed production blueprint.

1.2 Historical Context and the Need for a Foundational Redesign

The shift of screenwriting education from the industry floor to the academic classroom has been noted by scholars like Paul Gulino (2023), who highlights the loss of the apprenticeship model. In the Golden Age of Hollywood, writers learned within the collaborative, constraint-heavy environment of the studio system. The university setting, in its attempt to legitimize the discipline, often prioritized theory and structure, effectively sterilizing the writing process of its essential production context. This paper asserts that to rectify this systemic issue, a fundamental pedagogical redesign is required. The instruction must transition from a knowledge transmission model (focused on what to know) to a practice construction model (focused on how to act). This paper introduces the Scenario-Driven Pedagogy (SDP), a design framework developed to re-situated scriptwriting instruction within the authentic, production-driven environment from which it was historically derived.

1.3 The Design Research Imperative

The study presented here is a design research effort, aimed at establishing a theoretically grounded and operationally detailed model. It seeks to answer the fundamental design question: How can scriptwriting pedagogy be structurally reformed to ensure students develop screenplays as actionable production blueprints rather than merely literary texts? This approach is distinct from empirical research, as its primary output is not a set of findings, but a "usable, specified, and tested... intervention" (Reeves, 2006). The intervention proposed is the SDP framework itself.

2. Situating SDP: A Review of Competing Pedagogies

The SDP model was not developed in a vacuum. It is a direct response to the identified shortcomings of prevailing teaching methods. A brief review of these models clarifies the pedagogical gap SDP is designed to fill.

2.1 The Traditional "Workshop" Model

The most common model, borrowed from creative writing programs, is the "workshop" (Davis, 2021). In this model, students write pages, submit them, and receive peer and instructor feedback in a group setting. While valuable for developing voice and receiving critique, this model has two critical flaws in a production context. First, feedback is often subjective and "literary," focusing on character and theme rather than producibility. Second, it reinforces the "isolated artist" paradigm, failing to simulate the collaborative, high-pressure, note-giving environment of a professional writers' room or production meeting.

2.2 The "Master-Analyst" Model

This model, popularized by figures like Robert McKee, focuses on the intensive deconstruction of successful, canonical films. Students learn narrative structure by analyzing "masterworks." The pedagogical assumption is that by understanding the architecture of great films, students can replicate it (Jones, 2020). However, this "reverse-engineering" approach often fails. It teaches students to be excellent analysts but not necessarily competent generators of new material. It struggles to bridge the gap between recognizing a flawless plot point and creating one under the pressure of a blank page and a tight budget.

2.3 The "Rule-Application" Model

As mentioned in the introduction, this model (e.g., Syd Field's paradigm) presents screenwriting as a set of prescriptive rules and structural benchmarks (e.g., "The inciting incident must occur by page 10"). While providing a useful entry point for

novices, this model is widely criticized for promoting formulaic writing (Brown, 2022). It prioritizes structure over story and fails to account for the myriad of successful narrative forms that defy its rigid constraints. More importantly, it offers no guidance on the visual or logistical execution of the prescribed plot points. These models are not without merit, but they share a common failure: they treat the screenplay as a final literary product, not as the first, foundational document in a complex production chain. SDP diverges by redefining the “problem” of screenwriting as an integrated production challenge, not a solitary literary one.

3. Theoretical Foundations: The Three Pillars of SDP

3.1 Pillar I: Constructivism and Knowledge as Active Construction

Constructivism and Knowledge as Active Construction Constructivism, rooted in the work of Piaget and Vygotsky, asserts that learning is an active, idiosyncratic process where learners construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. Knowledge is not passively received but actively built.

In traditional screenwriting, the instructor defines the “rules” of good writing (e.g., “All scenes must have a clear objective”). In SDP, the principle of constructivism is operationalized by replacing direct instruction with problem design. The instructor’s role shifts from a “Sage on the Stage” to a “Guide on the Side” and, more importantly, a “Designer of the Problem.”

Challenging Assumptions: Students are not taught the importance of visual storytelling; rather, they are presented with a Constraint-Based Scenario (e.g., “Write a five-page script where no dialogue is permitted”).

Cognitive Conflict: The task forces a cognitive conflict. The student, realizing they cannot rely on exposition, must actively explore and construct techniques (e.g., body language, props, framing, sound design) to convey information and emotion. This aligns with Vygotsky’s (1978) “Zone of Proximal Development,” where the scenario provides the precise challenge that pushes the student just beyond their current capabilities.

Self-Discovery of Principles: The core narrative principle (e.g., “Show, Don’t Tell”) is thus not dictated but discovered and internalized through the struggle of problem-solving. This constructed knowledge is deeper, more durable, and more readily applied in new contexts.

3.2 Pillar II: Experiential Learning Theory and the Cycle of Reflection

The Experiential Learning Theory (ELT), as articulated by David Kolb (1984), defines learning as “the process whereby knowledge is created through the transformation of experience.” This process is described as a four-stage, iterative cycle that forms the dynamic engine of the SDP model.

Traditional education often stagnates in the Abstract Conceptualization (AC) stage—where concepts are explained—and rarely completes the final stage of active experimentation. Arts education, in particular, often skips the critical “Reflective Observation” (RO) stage, jumping from “Concrete Experience” (the draft) to “Active Experimentation” (the next assignment) without structured reflection (Schön, 1983). SDP is specifically engineered to ensure the continuous and compulsory completion of the full cycle in every assignment:

Concrete Experience (CE): The Draft. Students engage in the immediate experience of the writing task—the production scenario. This is the act of drafting the script under the given constraints.

Reflective Observation (RO): The Critique. The student observes and reflects on the experience. This occurs through structured peer reviews, table reads (where the script’s dialogue and pacing are physically embodied), and analysis of how the script performs under the production lens (e.g., “Is this scene too dark to light?” or “Does this location work?”).

Abstract Conceptualization (AC): The Insight. From the observations, the student forms abstract concepts. They may realize, for instance, that their protagonist’s objective was too vague or that their use of cross-cutting was confusing. This is the moment of genuine theoretical insight derived from practice.

Active Experimentation (AE): The Rewrite. The student uses the new understanding (AC) to actively test and modify the script (the rewrite). This crucial step closes the loop, applying the learned concept back into a new concrete experience, initiating the next cycle of learning. SDP embeds iteration as a non-negotiable principle, thereby forcing the completion of this cycle, turning the process of rewriting—often seen as a punitive task—into the primary mechanism of learning.

3.3 Pillar III: Situated Learning and Professional Identity

The Situated Learning Theory (SLT), pioneered by Lave and Wenger (1991), posits that learning is inseparable from the activity, context, and culture in which it occurs. It emphasizes that students must move from the periphery to the center of a Community of Practice (CoP), achieving what they term legitimate peripheral participation (LPP). The scriptwriting classroom is intentionally transformed into a simulated CoP—a “micro-production studio” or a writers’ room.

Professional Identity: Through Role-Based Scenarios (e.g., students act as a Showrunner, Staff Writer, or Director), they are compelled to adopt the professional identities associated with film production. This identity shift moves them away from the isolated “genius writer” stereotype towards the collaborative “problem-solving screenwriter” identity.

Authentic Tools and Context: The learning environment demands the use of authentic professional tools (industry-standard script formats, scene breakdown sheets, call sheets, and pitch decks). The artefacts of the learning process become the artefacts of professional practice. This includes mastering the specific language (argot) of production, learning to give and receive notes with professional brevity.

Legitimate Participation: By structuring assignments around shared, complex production challenges, students’ contributions are immediately validated by the demands of the “production.” The writing is necessary for the next stage (directing, lighting, editing), giving the writer’s work a legitimate functional purpose within the community. The result is the internalization of the cultural norms of the film industry—efficiency, clarity, and collaboration—as essential writing virtues.

4. The SDP Model: Guiding Principles and Operational Design

4.1 Principle 1: Authenticity

LeBron Authenticity demands that the learning task accurately reflects the cognitive, social, and procedural challenges faced by a professional screenwriter in a real-world production environment. Authenticity is often compromised by assignments that allow for limitless budgets or fantasy scenarios. SDP actively imposes production constraints to foster problem-solving creativity:

Logistical Constraints: Assignments must be tied to specific, limited production elements: e.g., using only available campus locations (e.g., a single classroom and a hallway), a maximum of two actors, or being confined to a single fixed camera position for the entire scene. Another example is the “found footage” constraint, where all story information must be justified through a diegetic camera.

Budgetary Constraints: Students may be required to write a scene with a hard, stated budget cap (e.g., “\$50 for props and costumes”), forcing them to use inventive staging rather than expensive production design.

Time Constraints: In Role-Based Scenarios (e.g., a “Writers’ Room” exercise), writers must deliver a polished sequence in a dramatically reduced timeframe (e.g., three hours), mirroring the intense pace of episodic television or last-minute rewrites. By simulating the friction and scarcity inherent in filmmaking, students learn that a great script is one that not only tells a compelling story but also manages resources intelligently.

4.2 Principle 2: Integration

The principle of integration mandates that scriptwriting cannot be taught as a purely literary discipline. It must be seamlessly interlocked with the entire production pipeline, from conceptualization to final cut. Every major script assignment under the SDP model requires mandatory deliverables that bridge the script with the technical and logistical realities of the set:

The Script and the Scene Breakdown: Students must accompany their script with an industry-standard scene breakdown sheet, identifying every prop, wardrobe item, visual effect, special makeup requirement, and cast member. This forces the writer to meticulously read their own work through the eyes of the Assistant Director and Production Designer.

The Script and the Visual Plan: Writers must provide annotated storyboards for their most critical, non-verbal sequence, or a director’s vision document detailing the planned mise-en-scène (blocking, lighting mood, camera movement) for a key scene. This ensures the writer is always thinking in visual and spatial terms.

The Script and the Budget: As a complement to the breakdown, students must create a “top-sheet” budget for their script, estimating costs for key “below-the-line” items (locations, props, extras). This directly links creative decisions (e.g., “a crowd scene”) to financial consequences.

The Script and the Pitch Deck: For long-form assignments, students must create a professional pitch deck, including a synopsis, character breakdowns, target audience analysis, and visual look-book. This integrates the script's creative content with its necessary market and business context.

4.3 Principle 3: Iteration

Iteration is the process-oriented core of SDP, replacing the single-submission model with compulsory, structured cycles of drafting, feedback, and rewriting. This aligns directly with Kolb's Experiential Learning Cycle. For iteration to be effective, feedback must be delivered not just by the instructor, but from various professional perspectives:

Peer-as-Crew Feedback: Students provide feedback to the writer not only as "readers" but as assigned crew members (e.g., the student acting as the "Director of Photography" must comment on the feasibility of the lighting cues; the "Producer" must comment on the cost of the proposed action).

The Table Read Protocol: Scripts must undergo formal, structured table reads, where actors (peers or external volunteers) read the script aloud. This is a critical RO stage, forcing the writer to immediately confront pacing issues, unnatural dialogue, and moments where internal subtext fails to translate into spoken performance.

Version Control: Students are required to submit all drafts, with a mandatory "Revision History" log detailing why specific changes were made, linking the change directly back to the AC (Abstract Conceptualization/Insight) gained from the previous feedback cycle (RO).

4.4 Principle 4: Scaffolding

Scaffolding refers to the support structures provided by the instructor to help the student achieve a task they could not accomplish independently. In SDP, scaffolding is crucial because the tasks are inherently ambiguous and complex. Cognitive Scaffolds: These help students structure their thinking about the problem. Examples include: Prompting Questions (e.g., "What does your character risk losing in this scene?" before writing dialogue) and Templates (providing a basic scene outline or character profile sheet).

Procedural Scaffolds: These guide the steps of the process. Examples include: Checklists (ensuring all production requirements are met before submission) and Step-by-Step Guides for formatting or creating scene breakdowns.

Metacognitive Scaffolds: These encourage students to reflect on their own thinking and learning. Examples include: Mandatory Reflection Journals that document their emotional and intellectual journey through a difficult rewrite, and Self-Assessment Forms where they rate their own adherence to the scenario's constraints before submitting.

5.Scenario Typology: Designing the Learning Environment

5.1 Type 1: Constraint-Based Scenarios

Constraint-Based Scenarios are designed to intentionally limit the writer's options, thereby forcing innovative, resourceful, and highly visual problem-solving. These scenarios counter the natural inclination toward excessive exposition or expensive solutions.

Table 1 Detailed Examples and Pedagogical Goals for Constraint-Based Scenarios

Scenario Example	Constraint Imposed	Pedagogical Goal
The Silent Witness	"No dialogue permitted for five consecutive pages. Only visual action, setting, and sound cues allowed."	Develop pure Visual Thinking; reinforce the principle of 'Show, Don't Tell.'
The Fixed Frame	"The entire scene (3 minutes of screen time) must take place in a single location, with the camera locked down to a single master shot."	Master Blocking and Staging; utilize the entire physical space to reveal character and plot.
The Minimalist Prop	"A central plot device must be a common, inexpensive item (e.g., a single piece of crumpled paper or a rubber band)."	Encourage Symbolism and Economy in prop use; avoid reliance on special effects.
The Budget Limit	"The scene must contain an action sequence, but the total prop/stunt budget is \$100."	Foster Logistical Awareness; force creative workarounds for complex action (e.g., implying action vs. showing it).
The Single Location	"The entire 10-page script must take place in one, mundane location (e.g., a laundromat, a bus stop)."	Maximize dramatic tension through character interaction and subtext, rather than spectacle.

5.2 Type 2: Role-Based Scenarios

Role-Based Scenarios immerse students in the social and professional dynamics of the film industry, focusing on communication, adaptation, and collaborative efficiency within a Community of Practice.

Table 2 Detailed Examples and Pedagogical Goals for Role-Based Scenarios

Scenario Example	Role Assigned & Task	Pedagogical Goal
The Showrunner's Room	"Students are divided into a "'Writers' Room'" (Showrunner, Staff Writers). They must collaboratively break, outline, and write the first act of an assigned TV pilot in one week."	Develop Collaborative Efficiency; understand hierarchy and compromise in a production environment.
The Last-Minute Rewrite	"The writer is told, hours before a "'scheduled shoot,'" that the lead actress has broken her ankle and the location is unavailable. The script must be rewritten now."	Train Adaptive Rewriting; emphasize that a screenplay is a fluid document that must serve production realities.
The Executive Pitch	"The writer must present their project to a panel of "'Executives'" (instructors/peers) using only visual aids and a verbal presentation (5-minute hard limit)."	Master Conceptual Clarity and Oral Presentation; differentiate between "'writing a script'" and "'selling a project.'"
The Director's Notes	"The writer is given highly specific, sometimes contradictory, notes from an imagined director and producer, and must synthesize a single, effective revision plan."	Practice Note Interpretation; learn to defend creative choices while integrating necessary feedback.
The "Punch-Up"	"A 'dead' scene (provided by instructor) lacks conflict. As a 'script doctor,' the student has 24 hours to rewrite it and make it compelling."	Focus on micro-skills of pacing, subtext, and conflict injection.

5.3 Type 3: Visual-Prompt Scenarios

Visual-Prompt Scenarios actively front-load the visual element of storytelling, ensuring that the script's genesis is rooted in images and space, rather than pure exposition.

Table 3 Detailed Examples and Pedagogical Goals for Visual-Prompt Scenarios

Scenario Example	Prompt Type & Task	Pedagogical Goal
The Stolen Image	"A single, non-contextual photograph (e.g., an empty room, a shadow on a wall) is provided. Write the 3-page scene that immediately precedes or follows the image."	Foster Image-to-Narrative Translation; force the creation of story and conflict from pure visual atmosphere.
The Auditory Scene	"Students are given a pre-recorded, abstract soundscape (e.g., muffled voices, industrial clanking, a distant scream). Write a scene where the soundscape drives the character's movement and fear."	Elevate Sound as a Storytelling Tool; integrate sound design into the initial writing phase.
The Abstract Mood	"A piece of abstract expressionist art or music is provided, conveying a specific, non-literal mood (e.g., 'Anxiety' or 'Tension'). Write a dialogue-driven scene that captures that specific mood."	Practice Emotional Resonance; move beyond plot mechanics to convey abstract feeling cinematically.
The Location Scout	"Students are sent to a real campus location, must take 5 photos, and write a scene that could only happen in that specific space, using its unique features."	Train the eye for "cinematic space"; ground the writing in physical reality.

6. Implementation Blueprint: A Four-Phase Curriculum Map

The SDP model can be systematically implemented over a standard 15-week academic semester, structured around four progressive phases that follow the maturation of the script from concept to final production blueprint.

6.1 Phase I: Conceptualization (Weeks 1–3)

Focus & Principle Applied: Authenticity & Situated Learning

Description: This phase is dedicated to immediate immersion. Instead of a "Syllabus Week," students are immediately placed into their Role-Based Scenarios (e.g., "You are now a staff writer for Studio X"). The instructor, acting as "Showrunner" or "Executive," introduces the central production problem for the semester (e.g., "We need a 10-page short film, limited to two locations and three actors"). Students form production teams (CoPs) and begin the conceptualization process by pitching

loglines and synopses, already framed by authentic constraints.

Key Activities: Introduction to industry format and professional roles. Release of the central Role-Based Scenario. Team formation and project pitching.

Deliverables (Integrated Artefacts): Role Assignment Charter, Logline/Synopsis Pitch (Verbal & Written), Preliminary Scene Breakdown of one key sequence.

6.2 Phase II: First Draft & Visualizing (Weeks 4–7)

Focus & Principle Applied: Constructivism & Integration

Description: Students engage in the “Concrete Experience” of writing the first draft. The instructor introduces targeted, smaller Constraint-Based Scenarios as “boot camp” exercises to build specific skills (e.g., a “Silent Witness” exercise) that feed into the larger project. The focus is on translating the concept into a visual blueprint, supported by the “Integration” principle. Students must produce visual plans (storyboards, floor plans) alongside their script pages, forcing them to construct their story visually from the outset.

Key Activities: Writing of the first full draft (CE). Visualization workshops (storyboarding, blocking). Introduction of a Constraint-Based Scenario mini-assignment.

Deliverables (Integrated Artefacts): Complete First Draft Script, Annotated Storyboards for one critical action sequence, Character Arc Documentation.

6.3 Phase III: Reflective Iteration (Weeks 8–11)

Focus & Principle Applied: Experiential Learning & Iteration

Description: This phase is the core of the Kolb cycle. The first draft is not graded as a final product but treated as the subject of reflection. The “Table Read Protocol” provides the “Reflective Observation” (RO) stage, where students hear their work aloud. This is followed by “Peer-as-Crew Feedback,” where students analyze the script from their assigned production roles. The instructor provides scaffolding to help students synthesize these (often conflicting) notes into an “Abstract Conceptualization” (AC) or a clear rewrite plan. The rewrite (AE) is the primary assessed task of this phase.

Key Activities: Structured Table Reads (RO). Peer-as-Crew Feedback sessions. Instructor consultation (Scaffolding). Mandatory Rewrite 1 (AE).

Deliverables (Integrated Artefacts): Revised Second Draft Script, Peer Feedback Forms, Mandatory Revision History Log (documenting insights).

6.4 Phase IV: Finalization & Production-Ready Package (Weeks 12–15)

Focus & Principle Applied: Situated Learning & Authenticity

Description: The final phase re-emphasizes the script’s professional function. Students complete their final revisions, guided by the logistical and budgetary constraints established in Phase I. The final assessment is not just the script, but the complete “Production-Ready Package.” This package serves as the “final exam,” demonstrating the student’s mastery of the writer’s full responsibility within a production pipeline. The course concludes with a final “pitch” or “greenlight meeting” where students present their final package as a viable, producible project.

Key Activities: Final revision guided by logistical constraints. Creation of the Production Package. Presentation and defense of the script as a viable project.

Deliverables (Integrated Artefacts): Final Production-Ready Script, Complete Scene Breakdown (for 100% of the script), Budget Estimate (Props/Locations), Final Reflection Journal on the writing process.

7. Discussion

7.1 Pedagogical Implications of Identity and Knowledge

SDP offers profound pedagogical implications by shifting the focus from the product (the script) to the process (the writing/filmmaking journey). From Literary Text to Production Blueprint: The model actively forces the transition from a literary mindset to a production mindset. When students must complete a Scene Breakdown (an integrated deliverable), they are forced to confront the hidden logistics within their writing—the unstated set dressings, the number of extras needed, and the complexity of the action lines. The script ceases to be an abstract story and becomes a highly detailed, executable instruction

manual.

Cultivating the Reflective Practitioner: By institutionalizing Iteration and requiring the completion of the Experiential Learning cycle, SDP trains students to be reflective practitioners (Schön, 1983). The student learns that professional mastery is not characterized by the absence of flaws in the first draft, but by the analytical skill and intellectual rigor applied during the revision process.

Fostering Resilience and Adaptability: The “Last-Minute Rewrite” and “Director’s Notes” scenarios, in particular, build professional resilience. Students learn to detach personal ego from their work, accept criticism as a necessary part of the process, and adapt their creative vision to serve the collaborative whole—a critical affective skill for industry survival.

Enhancing Transferability: Knowledge acquired through authentic, situated problem-solving is intrinsically more transferable to new, diverse contexts (Hmelo-Silver, 2004). A student who learns about ‘dramatic irony’ by solving a Constraint-Based Scenario (e.g., a short film where the audience knows the bomb is under the table, but the characters do not) will be better equipped to apply that concept across any genre or budget level than a student who merely wrote an essay defining the term.

7.2 Anticipated Implementation Challenges and Mitigation Strategies

The transition to SDP is not without institutional and instructional hurdles. Successfully implementing the model requires deliberate strategies to mitigate potential friction.

Challenge: Instructor Transformation: Instructors must pivot from being content experts delivering lectures to being Master Designers of Learning Environments and Process Facilitators. This requires a significant investment in faculty development and training on instructional design principles.

Mitigation: Institutional support must be provided for the co-development of a shared Scenario and Scaffolding Resource Bank, allowing new instructors to access proven task designs, successful student examples, and detailed facilitation guides.

Challenge: Assessment Complexity: Traditional grading systems, which prioritize the final submission, are inadequate for assessing the integrated, iterative nature of SDP. Grading the Revision History Log, the Reflection Journal, or the quality of Peer-as-Crew Feedback is complex.

Mitigation: The curriculum must adopt a Portfolio-Based Assessment model. Grades should be weighted heavily toward Formative Assessments (e.g., 60% of the final grade based on process, reflection, and integration of deliverables) and less on the final script’s subjective “quality.” Grading rubrics must clearly reward problem-solving under constraint and the depth of reflection in the iteration phases.

Challenge: Student Resistance: Some students, particularly those who identify as “pure writers,” may resist the production constraints, viewing them as an infringement on their creativity. They may balk at tasks they deem “non-writing” (e.g., budgeting, storyboarding).

Mitigation: This resistance must be addressed from Day 1 by framing the course’s objective not as “creative writing” but as “professional pre-production.” The Situated Learning framework is key: emphasizing that in the professional CoP, these tasks are the writer’s job. Success stories and guest speakers from the industry can reinforce this message.

Challenge: Resource Allocation: SDP is more resource-intensive than a traditional lecture. It requires space for table reads, potential access to actors (even from a drama department), and instructor time for process facilitation rather than just grading.

Mitigation: Strategic planning is essential. “Peer-as-Crew” feedback minimizes reliance on external experts. Leveraging free, industry-standard software for budgeting and breakdowns (e.g., Celtx, Trelby) can mitigate technology costs.

7.3 Limitations of this Framework

This paper presents a theoretical design framework, not an empirical study. As such, its claims of efficacy are, at this stage, purely logical and theoretically derived. The primary limitations are:

Lack of Empirical Validation: The SDP model has not yet been subjected to rigorous, comparative pedagogical research. Its effectiveness relative to traditional models is proposed, not proven.

Context-Specificity: The model is explicitly designed for practice-oriented film programs. Its applicability to more theoretical film studies programs, literary-focused creative writing degrees, or programs without a production component is questionable.

Scalability: The framework is presented in the context of a single-semester, short-film-oriented course. The complexity of

scaling SDP to manage a full-length feature screenplay or the collaborative, multi-semester arc of an episodic television series remains a significant, unaddressed challenge.

Conclusion

This paper has proposed the Scenario-Driven Pedagogy (SDP), an instructional design framework built to address the persistent gap between theory and practice in film production screenwriting education. By synthesizing principles from Constructivism, Situated Learning, and Experiential Learning, the SDP model reframes scriptwriting as a problem-solving process within an authentic, constraint-based production context. Its core contribution is not an empirical finding, but a robust theoretical blueprint for pedagogical change. Through its four principles—Authenticity, Integration, Iteration, and Scaffolding—SDP endeavors to shift the student’s identity from that of an isolated “writer” to a “production-aware filmmaker,” one who understands the script not as a literary artifact, but as an actionable blueprint for a collaborative craft.

As a theoretical framework, the next essential step for SDP is rigorous empirical validation. Future research must move beyond this design study to test its efficacy against traditional pedagogical models. Key directions should include quasi-experimental studies to compare student outcomes in production literacy and script producibility; longitudinal tracking of graduates to assess long-term professional integration and adaptability; and case studies to investigate the framework’s scalability for long-form narratives (like feature films) and its transferability to adjacent creative disciplines, such as interactive narrative for game design or client-based advertising.

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Research on the High-Quality Development Path of Vocational Education in Jiangxi Under the Dual Circulation Pattern——Based on the Collaborative Construction of Innovation Mechanisms and Supporting Systems

Lei Huang*, Xinghua Yan

Jiangxi Science & Technology Normal University, Jiangxi 330038, China

*Corresponding Author: Xinghua Yan, 13012572244@163.com

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Abstract: The dual circulation pattern is influencing the economic development of Jiangxi Province, mainly reflected in adjusting the industrial structure, optimizing the industrial chain, and expanding domestic demand. This means Jiangxi's vocational education must make adjustments to meet the talent needs of economic development. However, Jiangxi Province still faces many problems in government policy empowerment, integration of production and education, teaching staff, and cultural concepts. To effectively solve these problems, this study explores pathways for high-quality development of vocational education in Jiangxi Province under the dual-circulation framework. By examining collaborative mechanisms and supporting systems, it focuses on: improving industry-education integration frameworks, building industry-education partnerships, engaging stakeholders in educational initiatives, innovating teaching models and evaluation methods, establishing dual-qualified faculty management systems, and facilitating cross-regional and cross-school teacher mobility to address uneven distribution of teaching resources.

Keywords: Dual Circulation; Vocational Education; High-Quality Development; Innovation Mechanism; Supporting System

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1.Introduction

Against the background of global economic structure adjustment and China's high-quality economic development, the Party Central Committee has proposed giving full play to the advantages of China's super-large-scale market and gradually forming a new development pattern with the domestic big cycle as the main body and the domestic and international dual cycles promoting each other. The "Education Power Construction Plan Outline (2024-2035)" proposes accelerating the construction of a modern vocational education system and cultivating great power craftsmen, skilled craftsmen, and high-skilled talents. Under the background of "dual circulation" and "high-quality development of vocational education", how to provide talent support for Jiangxi's economy through vocational education has become an urgent proposition in the development of vocational education in Jiangxi Province.

2. Analysis of Existing Problems in the Development of Vocational Education in Jiangxi

2.1 Government Policy Empowerment: “Strong” but Not “Effective”

In April 2025, Jiangxi Province issued the Notice on the “Three-Year Action Plan for Vocational Education Teaching and Scientific Research Work (2025-2027)”, providing policy support for the high-quality development of vocational education in Jiangxi Province. In July 2025, Jiangxi Province issued the Notice on the “Implementation Plan for Vocational Education College Entrance Examination in Jiangxi Province”, improving the vocational education college entrance examination system and promoting the integration of vocational and general education. A series of policies issued by Jiangxi Province show the importance attached to vocational education. However, the policies are “strong” but not “effective”. Firstly, the accuracy of policy and financial support is insufficient, leading to unbalanced regional development of vocational education. Secondly, the sustainability of policies is lacking, and they have not been fully transformed into school-running vitality. Thirdly, there is a lack of collaborative school-running capacity among multiple subjects mentioned in the policies.

2.2 Integration of Production and Education: “Schools Are Enthusiastic, Enterprises Are Cold”

During the “14th Five-Year Plan” period, Jiangxi has 73 higher vocational colleges, including 5 vocational undergraduate colleges and 68 higher vocational colleges^[1]. In 2025, provincial higher vocational colleges plan to set up 279 new higher vocational specialty points, of which science, engineering, agriculture and medical specialty points account for 84.9%, and specialty points serving the “1269” Action Plan account for 77.8%. Centering on key industries such as non-ferrous metals, electronic information, and ceramics, 30 high-quality and distinctive integrated production-education golden specialties (groups) in vocational education have been selected and constructed^[2]. In the process of the rapid development of the integration of production and education in Jiangxi Province, there is also a phenomenon of “schools are enthusiastic, enterprises are cold”. The integration of production and education is a process involving multiple subjects, and the interest demands of various school-running subjects are different. Higher vocational colleges aim at talent training with a three-year cycle for talent cultivation; enterprises aim at profit, and talent training is adjusted according to enterprise development. Therefore, in the school-enterprise cooperative school-running, the interests of the two parties conflict, and enterprises are likely to resist school-enterprise cooperative school-running due to high costs.

2.3 “Double-Qualified” Teachers: Small Number and Uneven Distribution

The “2024 List of Proposed Recognition of ‘Double-Qualified’ Teachers in Jiangxi Province (Higher Vocational Colleges)” released in 2024 shows that there are 3,954 “double-qualified” teachers in the province, including 2,378 primary teachers, 837 intermediate teachers, and 739 senior teachers^[3], with primary teachers accounting for 60.14%, intermediate teachers 21.17%, and senior teachers 18.69% (see Table 1). There are several problems: firstly, the total number of “double-qualified” teachers is insufficient, and the proportion of teachers with senior titles is low. Secondly, the distribution of “double-qualified” teachers is uneven. Firstly, the distribution among schools is uneven. Jiangxi Manufacturing Vocational and Technical College has the largest number of “double-qualified” teachers, with 250, while Jiangxi Engineering Vocational College has the smallest number, with 2 (see Table 2), and the number of “double-qualified” teachers varies greatly among colleges and universities. Secondly, the regional distribution is uneven. The “double-qualified” teachers in Jiangxi Province are mainly concentrated in higher vocational colleges in Nanchang, with fewer distributions in other regions. Finally, the proportion of “double-qualified” teachers in science and engineering is relatively small. Taking the major categories of equipment manufacturing, energy power and materials, and electronics and information as examples, “double-qualified” teachers account for 24.2% in total, including 332 in the equipment manufacturing category, 66 in energy power and materials, and 560 in the electronics and information category (see Table 3). The existing teaching staff level cannot well meet the current economic development situation of Jiangxi Province.

Table 1: Proportion of Primary, Intermediate, and Senior “Double-Qualified” Teachers in Jiangxi

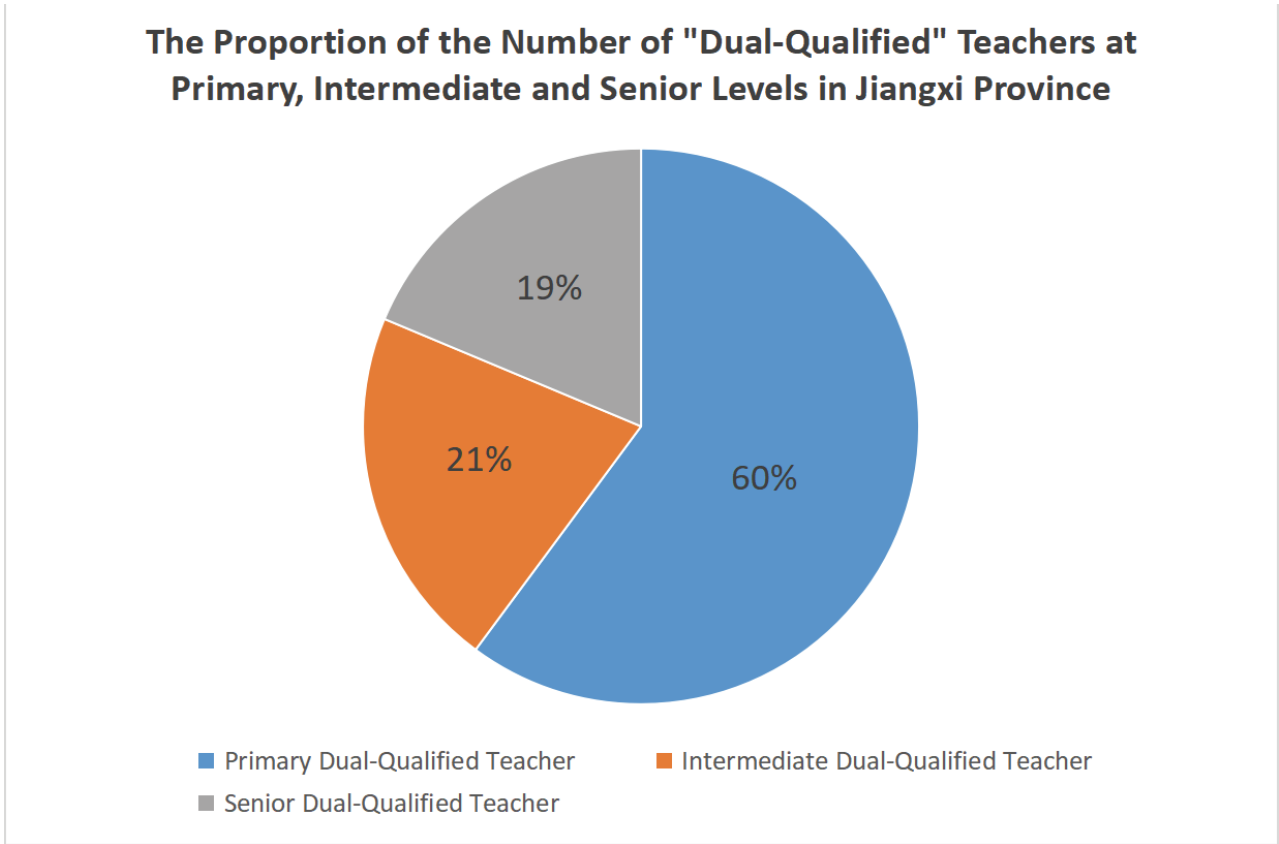


Table2:Summary of the Number of “Dual-Qualified” Teachers in Various Higher Vocational Colleges

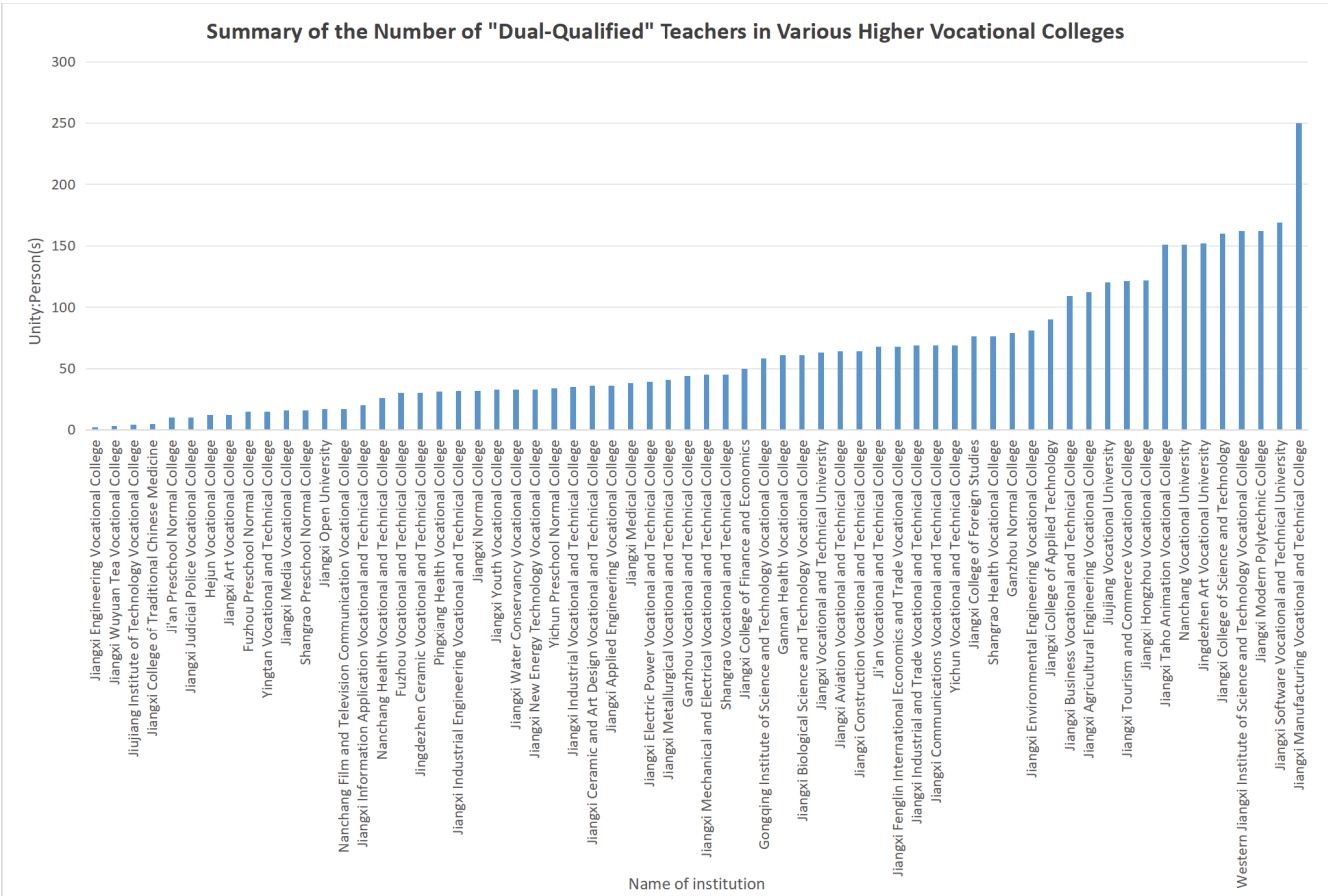
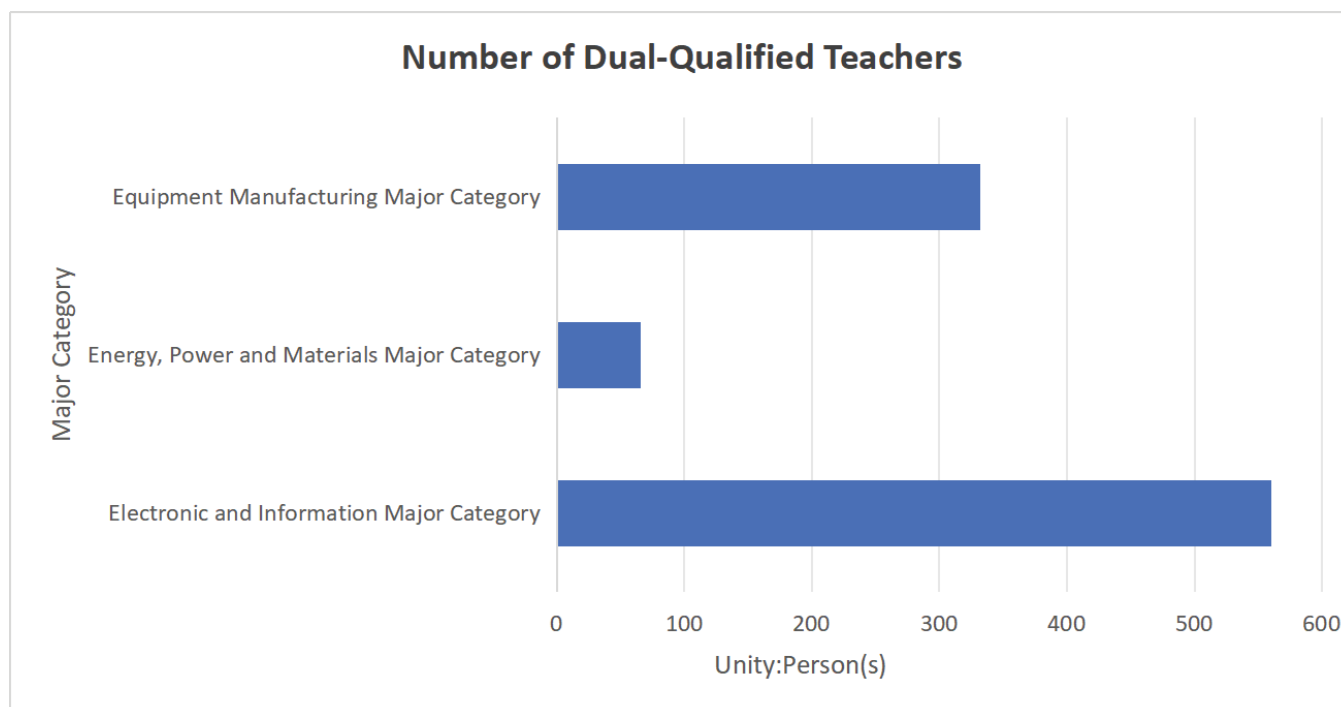


Table 3: Summary of the Number of “Dual-Qualified” Teachers in Equipment Manufacturing, Energy, Power and Materials, and Electronic and Information Major Categories in Jiangxi Province



2.4 Conceptual Breakthrough: Vocational Education Stigma

According to relevant survey data: among 2,765 respondents nationwide, more than half (55.3%) agree with the view that “vocational and general education ‘streaming’ is equivalent to ‘stratification’”; about 50% (50.1%) agree that “skilled workers are not as glamorous and decent as ‘white-collar workers’”; nearly half (45.4%) believe that “the importance of vocational education is still not fully recognized”^[4]. Although Jiangxi’s vocational education has achieved good results in various vocational skills competitions, the phenomenon of vocational education stigma still exists. There are many reasons for this phenomenon, the most important of which is the low salary level and job status. Through comparison, it is found that the monthly salary level of skilled workers in Jiangxi Province is quite different from that in Hong Kong, China and some developed countries (see Table 4).

Table 4: Comparative List of Monthly Salaries of Skilled Workers in Jiangxi, Hong Kong, China and Some Developed Countries

Country	Typical Occupations	Pre-tax monthly salary range (Unity:\$)
Jiangxi Province, China	Electrician	845-1,408
Hong Kong , China	Mechatronics Technician	2,662-3,944
Japan	Automotive Repair Technician	2,535-3,662
America	Certified Electrician	4,085-6,761
Britain	Plumber	3,239-4,930
Germany	Electrical Technician	4,225-5,915
Australia	Certified Electrician	4,930-6,761

3. Research Review on the High-Quality Development of Vocational Education Under the Dual Circulation Pattern

At present, the high-quality development of vocational education is an inevitable trend under the dual circulation pattern. Scholars have carried out research from aspects of policies, teaching staff, integration of production and education, and internationalization of vocational education. Firstly, research on the direction of high-quality development of vocational education. Ma Shuo (2022) explored the path of high-quality development of vocational education under the dual circulation pattern from the perspective of integrated development of internationalization and localization^[5]; Huang Yayu (2025) pointed out that the embedded development of integration of vocational and general education and integration of production and education is conducive to talent flow and integration, thereby promoting the high-quality development of vocational education^[6]. Secondly, research on the practical challenges faced by the high-quality development of vocational education. Su Hui (2022) pointed out that China is facing challenges such as a large gap in innovative skilled talents, insufficient matching between talent supply and demand and market demand, higher requirements for vocational education to serve economic modernization, and more complex needs for the sustainable development of vocational education^[7]. Thirdly, research on countermeasures for the high-quality development of vocational education. Wu Siqi (2024) proposed countermeasures from the perspective of constructing a talent training model, such as opening up academic channels, doing a good job in the integration of vocational and general education; integrating vocational knowledge and practical knowledge, academic certification and vocational qualification certification; improving textbooks and teaching methods, and implementing a teaching model combining training and education^[8]. By exploring the collaborative construction of vocational education innovation mechanisms and supporting systems, this paper helps the high-quality development of vocational education and provides knowledge-based, skilled and innovative compound talents for the economic development of Jiangxi Province.

4.Countermeasures for the High-Quality Development of Vocational Education in Jiangxi

4.1 Promote the Construction of Vocational Education Innovation Mechanisms

First, we will improve the mechanism for dynamic adjustment of majors. The “Opinions on Deepening the Reform of the Education System and Mechanism” clearly proposes promoting the formation of a talent training model with vocational education characteristics and improving the dynamic professional adjustment mechanism; the “Several Measures for Jiangxi Province to Deepen the Reform of Vocational Education and Technical and Vocational Education to Serve the High-Quality Development of the Industry” points out optimizing the dynamic professional adjustment mechanism; the “Implementation Plan for Optimizing the Layout and Structure of Higher Vocational College Specialties in Jiangxi Province” proposes that by 2025, the number of existing specialty points in higher vocational colleges will be optimized and adjusted by more than 20%, and the number of new specialty points will exceed 60%, serving the “1269” Action Plan and provincial key industrial chains^[9]. In 2024, the Jiangxi Provincial Department of Industry and Information Technology organized the compilation of the “2024 List of Shortage Talents in Key Manufacturing Industrial Chains in Jiangxi Province” (hereinafter referred to as the “List”), identifying 190 positions in the province that are highly related to 12 key industrial chains and have a large demand for talents, divided into three levels: “shortage”, “very shortage”, and “particularly shortage”^[10] (see Table 5). Among them, “particularly scarce” majors accounted for 55.26%. Jiangxi Province should timely adjust professional settings according to the content of the “List”, establish a talent demand list release mechanism led by human resources and social security departments, with the participation of industry competent departments, third-party institutions, key enterprises and other parties, and industry competent departments regularly release talent demand information. According to the forecast of job demand, guide schools to add urgently needed specialties, and eliminate or transform outdated specialties. For example, some higher vocational colleges in Jiangxi Province have timely revoked or suspended enrollment of some specialties and added some specialties (see Table 6) to actively connect with the national “Intelligent Manufacturing 2025” and Jiangxi Province’s “1269” Action Plan, cultivate a large number of high-quality applied, compound and innovative talents who can adapt to and lead the development of modern industries, and promote the further development of the industrial structure towards a “tertiary, secondary, primary” structure^[11].

Table 5: 2024 Annual Summary of Shortage Positions in Key Industrial Chains of Manufacturing Industry in Jiangxi Province

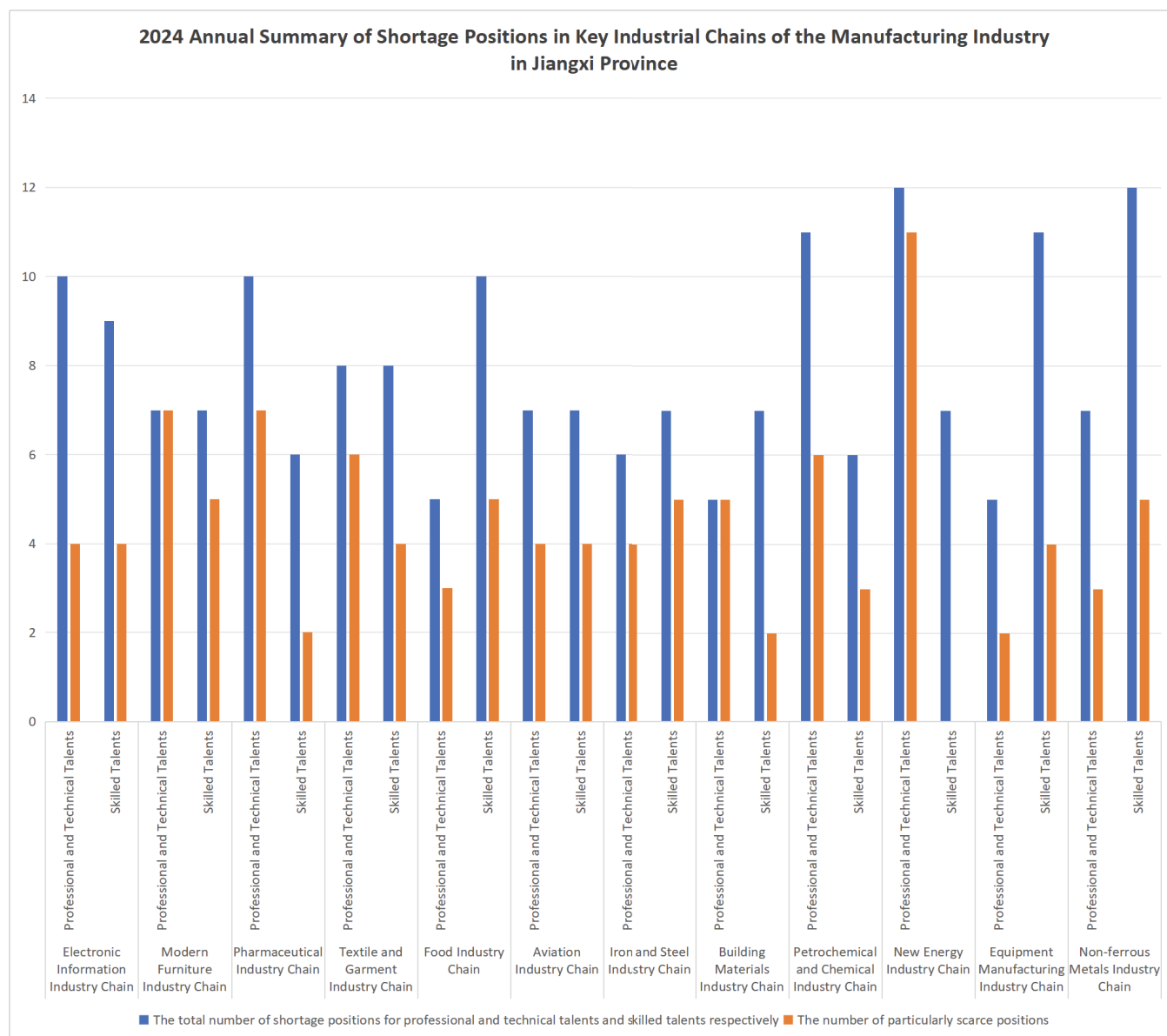


Table 6: Names of Withdrawn, Suspended and Newly Added Majors in Some Higher Vocational Colleges in Jiangxi Province

Serial Number	List of Higher Vocational Colleges	Names of Withdrawn/Suspended Majors	Names of Newly Added Majors
1	Jiangxi Modern Polytechnic College	Financial Service and Management, Environmental Monitoring Technology, Building Materials Testing Technology, Garden Engineering Technology	Industrial Internet, Industrial Robotics Technology, Digital Design and Manufacturing, Automobile Inspection and Maintenance Technology
2	Jiangxi Manufacturing Polytechnic College	International Economics and Trade	Omnimedia Advertising Planning and Marketing, Intelligent Mechatronics Technology
3	Jiangxi Agricultural Engineering College	Engineering Cost, Modern Logistics Management	/
4	Jiangxi Biological Vocational College	Automobile Inspection and Maintenance Technology, Tourism Management, Leisure Agriculture Operation and Management	/

Secondly, Improve the School-Running Mechanism of Integration of Production and Education. Stimulate the endogenous motivation of enterprises in Jiangxi Province to actively participate in the integration of production and education. Schools and enterprises jointly formulate professional talent training programs, and implement talent training models such as “order classes”, “modern apprenticeship pilot projects”, and “field engineers” under the background of the transformation of old and new kinetic energy; form an integrated production-education community. Talent training in the integrated production-education community should cover multiple stakeholders such as government departments, enterprise organizations, and institutional groups, and form a multi-directional interaction and virtuous cycle talent training model under the background of win-win cooperation^[12].

Thirdly, Implement the work-study combination teaching model. Schools and enterprises cooperate to establish internship and training bases, carry out high-quality “work-based learning”, allow students to learn professional knowledge and skills by completing typical work tasks of vocational positions around learning objectives, and improve their professional comprehensive quality and operational capabilities^[13]; actively set up learning factories to combine formal learning and informal learning. Carry out work-study combination teaching evaluation. With industry organizations as the leading body and multiple participating evaluation subjects, convert learners’ learning achievements from different sources into credits, store them in the “credit bank”, and realize the certification, accumulation and conversion of learning achievements.

Fourthly, establish the Management Mechanism of “Double-Qualified” Teachers. Accelerate the improvement of the teacher training system, focusing on two key issues: insufficient total number of teachers and structural shortage of science and engineering teachers. On the one hand, broaden the training entry channels and open up the transformation channel “from industry talents to teachers”, jointly build “double-qualified” teacher training bases with enterprises and scientific research institutions, carry out training for existing teachers to improve teaching skills and update subject knowledge, especially strengthen the training of practical teaching capabilities of science and engineering teachers, so that the training content can be accurately connected with industrial needs and teaching practice. On the other hand, construct a regional teacher resource sharing mechanism, divide teacher cooperation areas with Nanchang as the unit, promote developed areas and underdeveloped areas, cities and rural areas to sign teacher assistance agreements, form cross-regional teaching teams, and directly supplement the teacher resources in weak areas by regularly selecting excellent teachers for teaching support and on-site teaching. Promote the “strong supporting the weak” through college-university cooperation, focusing on giving play to the radiation and leading role of high-quality colleges and universities to narrow the teacher gap among different colleges and universities.

4.2 Accelerate the Construction of Supporting Systems

Build a social support system based on vocational colleges, including government, enterprises, professional institutions (organizations) and families.

Firstly, construct a social support system based on vocational colleges, including governments, enterprises, professional institutions (organizations) and families. policy formulation should not only guide the high-quality development of vocational education at the macro level, but also provide operational guarantees and support for specific problems in implementation; the Jiangxi Provincial Government can introduce corresponding laws and policies, clarify the powers and responsibilities of multiple school-running subjects, supervise the quality of talent training of subjects participating in vocational education, and promote the high-quality development of vocational education; increase the channels for the integration of vocational and general education, provide learners with various learning opportunities, build a “credit bank” so that the learning achievements obtained by learners in the workplace and communities can be recognized and converted, and establish a lifelong learning system.

Secondly, corresponding policy and financial support should be provided to enterprises actively participating in school-enterprise cooperative school-running to stimulate their motivation to participate in school-running. A special fund for vocational education can be established to give key support to vocational education characteristic school-running projects carried out in various cities.

Professional institutions (organizations) can provide curriculum development assistance for the shortage specialties in Jiangxi Province; actively develop “Professional Curriculum Standards” and “Professional Teaching Standards” to help vocational

colleges better carry out teaching of related specialties.

Thirdly, actively carry out vocational education lectures to introduce the employment prospects of vocational education, alleviate parents' anxiety about vocational education; various communities actively organize parents and students to visit higher vocational colleges, introduce the professional curriculum arrangements and employment scenarios of the schools to parents and students, and enhance their confidence in vocational education.

Fourthly, the Jiangxi Provincial Government, together with higher vocational colleges, industry organizations, top academic talents and "double-qualified" teachers, jointly record high-quality MOOCs, make full use of the National Smart Education Public Service Platform to develop online teaching resources for vocational education professional courses, practical courses and teacher training, use artificial intelligence technology to develop virtual simulation training, and jointly carry out an "online + offline" teaching model; break the limitations of traditional education in time, space and content. Create public products such as the World Digital Education Conference, the World Digital Education Alliance, the Global Digital Education Development Index, and authoritative digital education journals; actively host various vocational skills competitions to improve the international influence of Jiangxi's vocational education and promote its high-quality development.

4.3 Promote the Collaborative Construction of Innovation Mechanisms and Supporting Systems

The collaborative construction of innovation mechanisms and supporting systems essentially enables the "endogenous motivation" and "external guarantee" of vocational education to form a joint force through "policies setting directions, resources providing strong support, evaluation ensuring quality, and learning expanding dimensions". It not only avoids the "hanging in the air" of innovation mechanisms due to the lack of supporting support, such as professional adjustment without policy funds and integration of production and education without clear powers and responsibilities, but also prevents the "rigidity" of supporting systems due to the separation from mechanism practice, such as the disconnection between the evaluation system and talent training needs.

This collaborative construction will ultimately promote Jiangxi's vocational education to accurately respond to the talent needs of domestic industrial transformation, effectively serve the internationalization of vocational education and talent flow in the international cycle, and truly realize the goal of "mechanism innovation - system support - dual circulation adaptation - high-quality development".

5. Conclusion

Improve the dynamic professional adjustment, focus on the shortage professional types of Jiangxi's key industries, pay attention to related industries such as non-ferrous metal industry, new energy industry and electronic information industry, and reasonably add specialties in higher vocational colleges; improve the school-running mechanism of integration of production and education, construct an integrated production-education community, guide stakeholders to participate in school-running, and carry out new teaching models and teaching evaluation methods; establish a management mechanism for "double-qualified" teachers to realize the cross-regional and cross-school flow of teachers and solve the practical problem of uneven teacher distribution. Build a system supporting system for the mechanism innovation of vocational education. The Jiangxi Provincial Government can provide policy and financial support for the development of vocational education, consider multiple stakeholder communities, encourage professional institutions (organizations) to develop relevant curriculum standards and digital teaching resources, stimulate the vitality of enterprises to participate in school-running, alleviate social anxiety about vocational education, and jointly promote the high-quality development of vocational education in Jiangxi Province.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

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The Mechanism of Industry-University Integration in Private Universities: A Realistic Multiply Case Study

Min Zhao¹, Ting Yang², Ying Fu³, Qiang Zhong³

1.School of Hospitality Management, Macao University of Tourism, Macao, 999078, China;

2.Macao Polytechnic University, Macao, 999078, China;

3.School of Economics and Management, Nanchang Institute of Technology, Jiangxi, 330044, China

*Corresponding Author: Min Zhao, mz.zhao@live.cn

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Abstract: This study aims to reveal the core mechanisms driving effective industry-education integration in Business Administration programs at private universities in China, and to elucidate the specific mechanisms, contextual conditions, and causes that produce desired outcomes. The research adopts a realist evaluation paradigm and a multiple-case study design, conducting in-depth interviews with four distinct private universities and applying replication logic to construct and refine a “Context-Mechanism-Outcome” (CMO) configuration. It identifies three core mechanisms: collaborative governance, curriculum integration, and a dual-mentor system. These are not universally applicable but, depending on contextual factors like resource endowment and industry traction, combine to form three effective models: high-intensity integration, agile adaptation, and strategic focus. Theoretically, this study advances a contingency theory that shifts the understanding of industry-education integration from a static, universal perspective to a dynamic and context-sensitive one. Practically, the CMO framework serves as a diagnostic tool for designing contextualized strategies, with specific recommendations including the promotion of “lightweight project templates” and a “micro-certificate” system. The originality of this study lies in its application of realist methodology and replication logic to construct a robust causal model for industry-education integration, providing a reform roadmap for resource-constrained private universities—from strategic diagnosis to mechanism design.

Keywords: Private Higher Education Institutions; Industry-Education Integration; Business Administration Education; Case Studies; Realistic Evaluation

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1.Introduction

In the context of the global knowledge economy, the close collaboration between universities and industry, known as the integration of industry and education, has become a national strategy for countries to improve the quality of human capital and drive innovation (Dang et al., 2024; Vuoriainen et al., 2025). In China, a series of top-down policies explicitly require the higher education system to achieve organic integration of the education chain, talent chain, industrial chain, and innovation chain to meet the urgent needs of industrial upgrading (Guo et al., 2024; Zhuang & Zhou, 2023). As an important component of China’s higher education ecosystem, private universities and their large number of business administration programs face both enormous reform pressure and historical opportunities for differentiated development in this wave (Dang et al., 2024).

However, a significant gap exists between grand policy narratives and concrete organizational practices. Numerous studies and practices indicate that many university-industry collaborations still remain at a nascent and fragmented stage, such as student internships and that lack systematic planning and long-term sustainability (Dang et al., 2024; Vuoriainen et al., 2025).

The limited depth of corporate involvement fails to reach core aspects of talent cultivation, such as co-developing curricula and co-training faculty. (Vuoriainen et al., 2025). For private universities already facing challenges in resources, branding, and social recognition, the predicament of this “superficial collaboration” is particularly pronounced. (Dang et al., 2024; Guo et al., 2024). Therefore, breaking this deadlock and constructing a deep and sustainable industry-education integration model has become a core strategic issue concerning their survival and development (Vuoriainen et al., 2025; Guo et al., 2024).

Despite providing a valuable foundation for understanding industry-education integration, a critical gap persists in the existing literature. While most previous studies have focused on well-resourced public universities or remained at the level of macro-policy reviews, there has been relatively little in-depth mechanisms analysis of the private university context. (Caputo et al., 2022). Most importantly, while existing research often focuses on listing “best practices” (the “what”) or identifying barriers to collaboration such as a lack of trust and misaligned incentives, it fails to systematically explain the internal mechanisms that drive collaboration from superficial to deep, or the contextual boundaries of these mechanisms (the “how” and “why”). (O’Dwyer et al., 2023; Arranz et al., 2022). A core barrier is repeatedly mentioned: the widespread lack of fair, effective, and sustainable benefit-sharing mechanisms (O’Dwyer et al., 2023).

As rational market players, enterprises are fundamentally driven by the prospect of tangible returns when engaging in collaborations. However, when the value proposition is vague and the risks outweigh the benefits, their motivation to participate become constrained (Cantner et al., 2024; O’Dwyer et al., 2023). This gap underscores the need for a more explanatory theoretical framework to uncover the organizational and relational mechanisms that effectively align incentives, build trust, and co-create value (Czakoń et al., 2022; O’Dwyer et al., 2023; Cantner et al., 2024). This study aims to address this void developing a contingent model that explains the causal logic behind the success and failure of industry-education integration.

Grounded in the identified research gap, this study moves beyond mere description to undertake a diagnostic and explanatory inquiry. Adopting a realist research paradigm, it seeks to answer the following core questions within the context of Business Administration programs in private universities: (1) What are the core mechanisms that drive deep industry-education integration? (2) How do these mechanisms vary across different contexts, such as resource endowments, geographic location, and industry linkages? (3) What are the causal relationships between these contexts, mechanisms, and integration outcomes? By addressing these questions, this study aims to make a dual contribution: theoretically, by constructing a transferable CMO (Context-Mechanism-Outcome) configurational framework to advance the field from universalistic to contingent thinking; and practically, by providing a contextualized and actionable blueprint for institutional reform and decision-making for diverse private universities.

2. Theoretical Framework

To systematically reveal the inherent causal logic of industry-education integration, this study constructs a multi-level theoretical framework that uses the realist evaluation paradigm as its core analytical lens and synthesizes macro-level institutional ecosystem theory with meso-level curriculum design philosophy, which is designed to open the “black box” behind divergent outcomes of integration practices.

2.1 Analysis Lens

The theoretical foundation of this study is the Realist Evaluation methodology and its core analytical tool—the Context-Mechanism-Outcome (CMO) framework. The core question of the Realist methodology is not “Does this project work?”, but rather “What works, for whom, under what circumstances, and why?” (Wong et al., 2016; Warren et al., 2022). It argues that the success or failure of any social project, such as industry-education integration, is not determined by the program activities themselves, but by how specific contexts activate underlying mechanisms, which in turn produce particular outcomes. Its core causal logic can be expressed as: Context (C) + Mechanism (M) = Outcome (O).

Context (C) refers to the background conditions that influence whether a mechanism can be activated. In this study, context includes external factors such as institution resource endowments, local economic structures, and government support

policies, as well as internal conditions like the history and culture of the cooperating parties (Wong et al., 2016; Harris et al., 2024) .

A mechanism (M) denotes the underlying causal force that drives outcome, typically manifested as the reasoning, beliefs, and responses of participants within a program. For example, a fair distribution of benefits (project resources) may activate the belief among corporate managers that “cooperation is mutually beneficial” (mechanism), thereby motivating them to commit more core resources (Rees et al., 2024) .

Outcome (O) encompasses both expected and unexpected effects of a program. These may include graduate employment rate, improvement in students’ practical skills, as well as negative results such as the breakdown of cooperation (Wong et al., 2016; Jagosh et al., 2012) .

The introduction of the CMO framework allows this research to move from a simple “input-output” description to constructing a more refined and explanatory contingency theory. Instead of seeking a universally applicable “best practice,” it aims to reveal a set of “CMO configuration” that clarify under what conditions different types of industry-education integration strategies can succeed (Warren et al., 2022; Nielsen et al., 2024) .

2.2 Components of CMO configuration

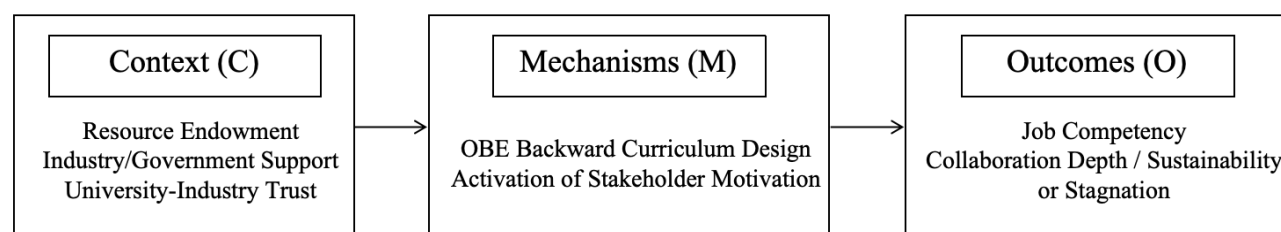
This study employs the Triple Helix Model and Outcome-Based Education (OBE) theory to operationalize the components of the CMO framework.

The Triple Helix Model-capturing the interactions among universities, industry, and government-serves as the core force shaping the macro-context (C) for industry-education integration . Government policy guidance, industry’s technological demand and market logic, and higher education institutions’ talent development missions collectively form the external conditions that influence whether integration mechanism can be activated (Cai & Lattu, 2022) .

Outcome-based education (OBE) is regarded as a key meso-level mechanism (M). By shifting the educational focus from “teaching inputs” to “learning outcomes” OBE establishes a common “language system” between universities and enterprises. Specifically, the OBE closed loop- centered on “job competency profiles → curriculum mapping → learning outcome evidence portfolios” - functions as an organizational routine that internalizes corporate talent standards into the teaching process (Syed et al., 2022; Pereira et al., 2024) . The efficacy of this mechanism lies in its provision specific operational focuses and evaluation standards for deep collaboration. This theoretical integration reframes OBE beyond a mere pedagogical concept, reinterpreting it as a boundary object that facilitates cross-boundary collaboration within specific organizational contexts. It provides a common communication platform and collaborative goals for actors from different organizational cultures (academia and industry), thereby activating deeper levels of cooperation (Wlazlak & Säfsen, 2025; Carlile, 2002) .

In summary, guided by the realist evaluation paradigm, this study treats the context (C) - mechanism (M) - outcome (O) configuration as the fundamental causal unit for explaining success and failure in industry-education integration. Specifically, contextual conditions (C) such as the university resource endowment, regional industrial ecosystems, and government initiatives-activate collaborative mechanism (M) between universities and enterprises, ultimately affecting the quality of talent cultivation and the sustainability of cooperation (O). This analytical framework is detailed in Figure 1 .

Figure 1: Realistic CMO Analysis Framework



3. Research Methods

To systematically construct and test the theoretical propositions outlined above, this study adopts a qualitative, multi-case comparative research design. This approach is chosen to facilitate in-depth exploration and systematic comparison, with the

goal of producing theoretical insights capable of analytical generalization.

Research Design. The fundamental objective of this study is to answer the questions of “how” and “why”—specifically, to explore the underlying mechanisms of industry-education integration and the boundary conditions under which they operate. Therefore, a qualitative multi-case study approach is an ideal choice, as it allows for deep investigations within authentic, complex real-world contexts (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). This study aims not for statistical generalization based on random sampling, but for analytical generalization based on theory (Flyvbjerg, 2006). The core logic for achieving this is replication logic, not sampling logic (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). This means the findings will be used to engage with, refine, or expand existing theories. Cases are treated as testing grounds for a series of theoretical propositions; through systematic cross-case comparison, patterns and mechanisms that transcend the idiosyncrasies of individual cases are identified (Eisenhardt, 1989; Flyvbjerg, 2006).

Case Selection. Following the replication logic, this study employs a theoretical sampling (or purposive sampling) strategy for case selection (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). To maximize the potential for theory construction, a maximum variation design is utilized. Four business administration programs from private universities were selected as research cases, based on the key contextual dimensions identified in the aforementioned theoretical framework (Eisenhardt & Graebner, 2007; Valtakoski & Glaa, 2024). This design enables both literal replication (where similar outcomes are anticipated in cases with similar contexts) and theoretical replication (where different, yet theoretically predictable, outcomes are anticipated in cases with different contexts), thereby strengthening the robustness of the emerging theory and clarifying its boundary conditions (Eisenhardt, 1989; Foster, 2024).

Table 1: Case Introduction and Context Comparison Dimensions

Case	Resources and Environment	Geographical location	Industry traction strength	Core Features Overview
University A	Abundant	Coastal	Strong	Located in a high-tech industrial zone, it has established in-depth partnerships with multiple large technology companies and offers specializations in Digital Marketing and E-commerce.
University B	Constrained	Inland	Weak	Based in a city dominated by traditional manufacturing, it primarily collaborates with small and medium-sized private enterprises, focusing on traditional Production Management and Marketing.
University C	Abundant	Coastal	Weak	Although situated in a developed region, its industry partnerships remain traditional. Collaboration is largely limited to routine internships, with limited exploration of deep integration.
University D	Constrained	Inland	Strong	Leveraging a government-led emerging industrial park, it has formed close ties with a specific industrial chain (e.g., new energy vehicles). Despite limited resources, collaboration is highly focused.

Data Collection and Analysis. The primary data source for this study is semi-structured in-depth interviews. The selection of interviewees follows the principle of “multi-source triangulation,” with the samples for each case university encompassing internal personnel, enterprise collaboration partners, and external observers (Dunwoodie et al., 2023; Gioia et al., 2012). For data analysis, an iterative analysis strategy was employed, where analysis proceeded concurrently and cyclically with data collection (Gioia et al., 2013; Gioia et al., 2022). The process began with within-case analysis for each individual case to construct its initial CMO chain (Gioia et al., 2022). This was followed by a cross-case synthesis, utilizing replication logic for theoretical refinement: literal replication helped identify common mechanisms, while theoretical replication revealed how contextual differences moderate these mechanisms (Grimm et al., 2024). Data collection continued until theoretical saturation was achieved, indicated when new first-order concepts no longer generate new primary themes or key mechanisms, ultimately leading to the development of a refined integration CMO framework (Dunwoodie et al., 2023; Gioia et al., 2012).

Research Rigor and Ethical Considerations. To ensure the rigor of the research process and the reliability of the results, this study implemented multiple strategies to uphold the trustworthiness of qualitative research, such as: member checking (Anfara

Jr et al., 2002; Sahakyan, 2023) , establishing a clear audit trail (Anfara Jr et al., 2002) , and employing dual independent coding (Burke et al., 2024) . Concurrently, this study strictly adhered to academic ethical standards. All interviews were conducted only after obtaining informed consent from participants. Furthermore, all collected data were anonymized to protect participants confidentiality (Lewis & Quinnell, 2024) .

4. Research findings

The core finding of this study is that effective industry-education integration is not driven by any single best practice, but rather by different configurations of a set of core mechanisms within a specific context. Unlike the “checklist” approach prevalent in existing literature, this research reveals a deeper causal narrative: why do some resource-constrained universities succeed in industry-education integration, while some well-resourced ones fail? To address this core question, this chapter will first demonstrate, through rigorous data analysis, how three fundamental mechanisms driving deep integration emerged systematically from the interview data. It will then reveal how these mechanisms-moderated by both resource endowment and industry linkage strength-evolve into three distinct pathways to success.

4.1 Deeply Integrated Core

This study strictly adheres to the standards of qualitative research rigor advocated by Gioia et al., constructing a complete data structure through an iterative coding process, from raw data (first-order concepts) to theoretical themes (second-order themes), and finally to overarching constructs (aggregate dimensions). Table 2 visually presents this analytical process. It serves not only as a “roadmap” for subsequent narrative but also as core evidence of the methodological rigor of this research. It clearly demonstrates how the three aggregate dimensions—“Synergistic Governance,” “Curriculum Integration,” and “Dual-Mentorship”—are grounded in and systematically constructed from the interview data

(i) Synergistic Governance

Collaborative governance mechanisms are the cornerstone of all deep integration practices. As illustrated in Figure 4-1, this aggregate dimension is composed of second-order themes such as “Community Consciousness,” “Joint Decision-Making Authority,” “Institutionalized Communication Channels,” and the “Establishment of Procedural Trust.” It provides institutional guarantees for solving the inherent core challenges in university-enterprise cooperation by establishing a joint decision-making platform that transcends the traditional client-vendor relationship and ensures equal rights and responsibilities. For example, a senior executive from a partner company of University A emphasized, “We are not client and contractor; we are a community with a shared future.” This quotation vividly embodies the second-order theme of “Community Consciousness.” This shift in mindset is a prerequisite for deep collaboration to occur.

The extreme importance of this mechanism is most strikingly highlighted by the failure of Case C. Despite abundant resources, the governance platform at University C was merely symbolic. As one interviewee noted, “meetings were not just for tea and chat”- but substantive dialogue failed to materialize. This resulted in enterprises remaining in the passive role of “resource provider” rather than becoming “co-owner,” which directly prevented the activation of deeper collaborative mechanisms. Consequently, the collaboration remained superficial, powerfully demonstrates that synergistic governance is a necessity, not merely a “nice-to-have.”

(ii) Curriculum Integration

If synergistic governance establishes the “skeleton” of collaboration, then the integrated curriculum mechanism constitutes the “flesh and blood” that fills it out. This aggregate dimension is built upon second-order themes such as “backward design logic,” “visualization of job competency requirements,” “precise matching of curriculum and competency,” and “outcome-based multi-dimensional assessment.” It accomplishes the systematic internalization of corporate talent standards into the teaching process and objectives of the university.

The core operational process of this mechanism is a dynamic closed loop. First, the university and the enterprise jointly develop a “competency profile” for the target job position. As one industry expert stated, “We start by mapping out the exact profile of the ideal candidate for this role, listing each required competency point by point.” This process exemplifies the “visualization of job competency requirements.” Next, the teaching team employs backward design to construct the curriculum system based on the profile, forming a “curriculum map” to ensure that “every course aligns directly with

this ‘competency map,’ keeping us on track.” Finally, assessment is conducted through a diverse “Portfolio of evidence”—including project reports and enterprise evaluations—shifting the focus from “what was taught” to “what was learned and what can be done.” The efficacy of this mechanism lies in its provision of concrete operational focuses and evaluation criteria for deep bilateral collaboration.

(iii) Dual-Mentor System

A normalized and controlled dual-mentor mechanism is the “last mile” for deepening integration and connecting theory and practice. As shown in Table 2, its core second-order themes include “Routine and Inclusive Mentorship” and “Quality Control and Incentive Mechanisms.” It aims to embed industry experts throughout the talent development process, facilitating the transfer of tacit knowledge. An effective dual-mentorship system is not a privilege reserved for a few top students, but an institutionalized arrangement—as one program coordinator noted, “Starting from their second year, every student is assigned two mentors.” This ensures the inclusivity and accessibility of mentorship.

More importantly, quality control is crucial. An industry mentor emphasized, “Being a corporate mentor isn’t just an honorary title. We have clear guidance manuals and evaluation criteria.” This reflects the operationalization of the “Quality Control and Incentive Mechanisms.” University D exemplifies this through a “rights–responsibility alignment” system, linking the dispatch of qualified mentors to enterprises’ eligibility for alliance benefits, thereby ensuring commitment and quality. In contrast, the absence of clear incentives and management mechanisms in Case C resulted in low engagement from corporate mentors, ultimately reducing the mechanism to a mere formality. This further underscores the systemic importance of these core mechanisms in achieving meaningful integration.

Table 2: Data Structure of the Core Mechanism of Deep Integration

1 st -order concepts (Representative interview Quotations)	2 nd -Order Themes (Research-Derived Theoretical Labels)	Aggregation Dimensions
“We are not client and contractor; we are a community with a shared future.” “Meetings were not just for tea and chat—we can actually make final decisions on curriculum budgets.” “Industry partners are deeply involved from the very beginning, starting with the top-level design.”	Community Consciousness Joint Decision-Making Authority Institutionalized Communication Channels Establishment of Procedural Trust	Synergistic Governance
“We start by mapping out the exact profile of the ideal candidate for this role, listing each required competency point by point.” “Every course aligns directly with this ‘competency map’, keeping us on track.” “The final evaluation isn’t based on what the teacher tested, but on the ‘portfolio’ students produce—and whether industry recognizes its value.”	Backward Design Logic Visualization of Job Competency Requirements Precise Curriculum-Competency Alignment Outcome-Based Multi-Method Assessment	Curriculum Integration
“Starting from their second year, every student is assigned two mentors: one from the university and one from the enterprise.” “Being a corporate mentor isn’t just an honorary title. We have clear guidance manuals and evaluation criteria.” “When companies send mentors, we also grant them priority in other collaborative projects.”	Routine and Inclusive Mentorship Quality Control and Incentive Mechanisms Tacit Knowledge Transfer Rights–Responsibilities Alignment	Dual mentor system

4.2 The moderating role of context

The analysis based on theoretical replication further reveals that the core mechanisms identified are not universal tools with fixed forms. Their specific manifestations, combinations, and ultimate effectiveness are profoundly shaped by key contextual factors. This study finds that Resource Endowments and Industry Traction are the two most critical moderating variables. Their varying levels of strength combine to produce three distinct successful models of industry-education integration and one failed model.

Resource Endowment refers to the amount of internal resources that universities have available for industry-education

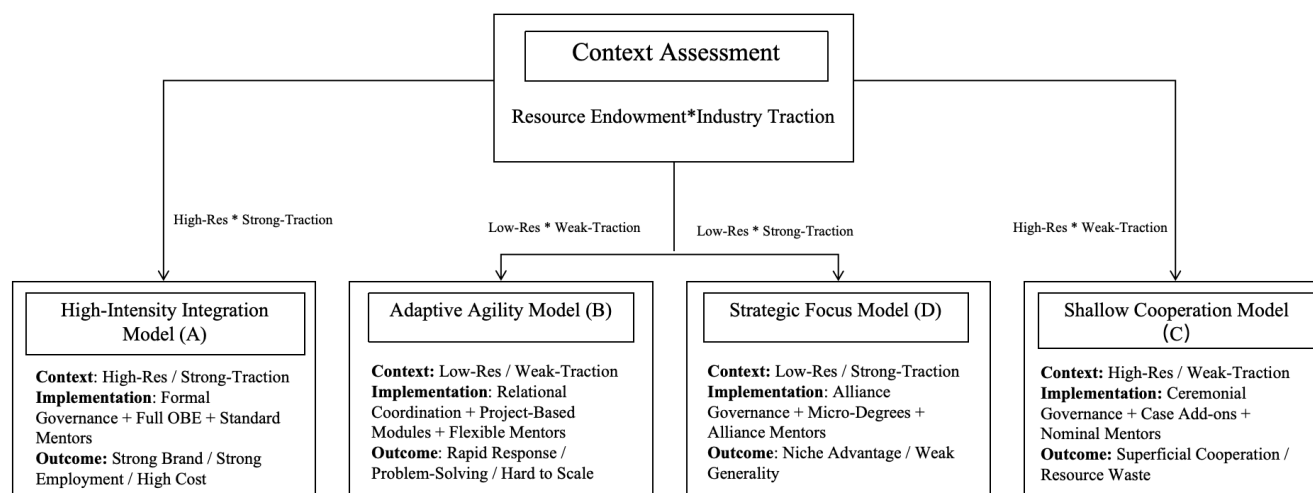
integration, such as financial, human, and brand resources.

Industry Traction denotes the strength of the intrinsic motivation for deep collaboration with universities, driven by factors such as the pace of technological iteration within the partner industry and the scale of its talent gap.

4.3 Contingency Paths for Industry-Education Integration

Different combinations of resource endowments and industry traction shape, constraint, and amplify the three core mechanisms-synergistic governance, curriculum integration, and the dual-mentor system- ultimately resulting in three identifiable and operational successful paths, as well as one typical shallow collaboration path. Specifically, this study identified three effective models: High-Intensity Integration (A), Agile Adaptation (B), and Strategic Focus (D)- alongside one high-risk model, Shallow Collaboration (C). These four models do not simply represent “good or bad” outcome; rather, they reflect viable pathways- demonstrating the principle of Equifinality- under different contextual conditions, as shown in Figure 2.

Figure 2: Contingency Path Model for Industry-Education Integration



(I) High-intensity fusion mode (Case A)

Context (C): Characterized by an ideal setting of abundant resources and strong industry traction. Mechanism (M): This advantageous context activates institutionalized, high-investment «heavy» integration mechanisms. Institution A established a «Strategic Committee» with Global 500 companies, enabling joint decision-making on the curriculum. Ample resources allowed for a systematic OBE curriculum redesign, with detailed intellectual property agreements safeguarding collaborative R&D interests. Outcome (O): This model produces graduates with strong competitiveness in the job market and helps the institution build a distinctive brand identity. However, its high operational costs and relatively rigid processes make it difficult for resource-constrained institutions to replicate.

(II) Agile Adaptive Model (Case B)

Context (C): Marked by a challenging environment of constrained resources and weak industry traction. Mechanism (M): Facing dual constraints of low engagement from large enterprises and limited internal resources (Context C), this context activated a strategy where Institution B's leaders leveraged personal social capital to create informal governance platforms, such as «Entrepreneur Luncheons» (Mechanism M). Curriculum reform followed a «focused breakthrough» approach, developing «project-based course modules» to lower the participation barrier for SMEs through «short, simple, and fast» collaboration models. Outcome (O): This model effectively enhanced the institution's capacity to serve the local economy. However, its sustainability is highly dependent on a few key individuals, making it difficult to scale.

(III) Strategic Focus Model (Case D)

Context (C): Defined by a unique scenario of constrained resources but strong industry traction (facilitated by an external industrial cluster). Mechanism (M): Resource constraints (Context C) compelled Institution D to seek external alliances to compensate for its weaknesses. Coordinated by the local government, the school co-established a «Talent Development

Alliance» with multiple firms within the industrial cluster. This alliance-based governance structure, through resource pooling, activated a «rights–responsibilities alignment» mechanism in the dual-mentor system, where firms viewed deep participation in talent development as an «obligation» for receiving policy support. Outcome (O): This model enabled the institution to develop a powerful, hard-to-replicate advantage in talent cultivation for a specific industrial sector. However, its success is highly dependent on the stability of the external industrial ecosystem.

Table 3 : Cross-Case Matrix of CMO Configuration for Industry-Education Integration

Mode Type	Core Context (C)	Adaptive form (M) of the Core Mechanism	Key Results (O)	Representative Case
High-intensity fusion mode	Resources: Abundant Industry-driven: strong	Governance: Institutionalized, formal Strategic Committee Curriculum: Systemic, full-coverage OBE restructuring Mentorship: Well-funded, standardized, and comprehensive system	Graduates exhibit strong job competency; significant joint innovation outcomes. However, entails high operational costs and limited flexibility.	University A
Adaptive Agility Model	Resources: Constrained Industry-driven: Weak	Governance: Informal, relationship-driven communication platforms Curriculum: «Focused-breakthrough» project-based modules Mentorship: Relies on personal commitment and non-material incentives	Enhances the institution's regional service capability and students' practical problem-solving skills. However, faces challenges in sustainability and scalability.	University B
Strategic Focus Model	Resources: Constrained Industry-driven: strong	Governance: Industry cluster-driven alliance governance Curriculum: Highly customized industry micro-programs Mentorship: Collective, obligation-rights aligned system	Cultivates a strong talent cultivation advantage in specific sectors, effectively offsetting resource constraints. However, faces tests in model transferability and developing students' general competencies.	University D
Shallow Cooperation Model	Resources: Abundant Industry-driven: Weak	Governance: Symbolic, formalistic joint meetings Curriculum: Add-on, marginalized case insertions Mentorship: "In-name-only," lacking management and incentives	Maintains basic internship cooperation but fails to enhance talent cultivation quality or institutional branding. Resource advantages are not translated into integration benefits.	University C

5. Conclusion

The central thesis of this study is that effective industry-education integration is not a set of easily replicable “best practices” but a dynamic, context-dependent ecosystem. Its success hinges on whether an institution can identify and cultivate a compatible combination of core mechanisms tailored to its unique context. This chapter situates these findings within the broader scholarly landscape, engages in dialogue with existing theory to elaborate their theoretical contributions, and develops a diagnostic framework for practice and policy.

5.1 Theoretical Contributions

This study's primary theoretical contribution is to advance University-Industry Collaboration (UIC) research beyond a quest for universal “success factors.” It shifts the focus from a “variable-oriented logic” to a “configuration-oriented logic” that emphasizes equifinality and context-dependence. By constructing a contingent model based on CMO configurations, it challenges the linear, additive assumptions implicit in prior efforts to compile checklists of success elements. The discovery of three distinct yet equally effective integration pathways demonstrates that success is not additive but configurational—achievable through entirely different “recipes.” This provides a novel equifinality perspective for UIC research.

Second, integrating Resource Dependence Theory (RDT) and Institutional logics perspectives provides a deeper causal explanation for this contingent model. We argue that the heightened resource dependence of private universities (an RDT

lens) furnishes the fundamental motive for collaboration, while the conflict between “academic logic” and “market logic”—stemming from their embeddedness in different institutional fields—constitutes the core dilemma. Within this framework, core mechanisms like “synergistic governance” are revealed as micro-level solutions crafted by organizations to manage external dependencies and resolve logic conflicts. This provides the crucial micro-foundation for understanding how macro-level institutional models like the Triple Helix are operationalized at the organizational level.

Finally, the study further illuminates the specific operational dynamics of these micro-solutions. Taking the “curriculum integration” mechanism as an example, we reconceptualize its core output (e.g., the “job competency profile”) as a boundary object. By providing a shared focus for collaboration endowed with “interpretive flexibility,” it bridges the communication gap between academics and practitioners belonging to different “thought worlds,” facilitating effective knowledge translation rather than mere transfer. This finding deepens our understanding of the social properties of knowledge-sharing tools in cross-organizational collaboration.

5.2 Implications for Practice and Policy

Table 4 : Contingency Optimization Strategy Framework for Multiple Stakeholders

Stakeholders	Core challenges	Optimization strategy recommendations
University Administrators	Insufficient internal incentives lead to a fragmented drive for reform; the curriculum is rigid and out of touch with industry; and teachers lack practical skills.	Strategic diagnosis: First, locate your position in the “resource-traction” matrix.
		High-intensity scenario: Establish a physical collaborative office and incorporate the effectiveness of industry-education integration into the core evaluation system for teachers.
		Agile adaptation to the situation: Empower front-line teachers and department leaders by granting them the autonomy to develop “lightweight projects” and establishing special rewards.
Enterprise	There is insufficient motivation to participate and a vague sense of value; co-operation remains superficial, with no willingness to invest core resources; and the barriers to participation are high for SMEs.	Strategic Focus Context: Concentrate the resources of the entire college to connect with the core industry chain and establish a “dual” teacher development path.
		Value proposition design: Shift from accepting internships to co-creating courses and co-evaluating projects, providing a clear menu of shared benefits.
		SME Solution: Vigorously promote the standardized “4-6 Week Lightweight Project” template, focusing on solving a specific, small-scale management problem to achieve low cost and quick returns.
Government/Industry Association	Lack of targeted policy support and incentives; information asymmetry and difficulty in sharing resources; legal and compliance risks in cooperation.	Large enterprise solutions: Promote the joint construction of joint laboratories and data sandboxes, and jointly apply for research and development projects.
		Institutional supply: Establish special funds/tax incentives that match the integration model; take the lead in establishing regional or industry-specific “micro-certification” certification systems and credit recognition standards.
		Platform establishment: Following the example of Case D, establish a cross-university “industry-college alliance” in key industrial sectors, providing start-up funds and a shared platform.

The CMO framework developed in this study holds not only theoretical value but can also be translated into an actionable framework for multiple stakeholders, serving both diagnostic and guiding functions. Its core principle is to emphasize that any effective improvement strategy must begin with an accurate diagnosis of one’s own context. Guided by this principle, the framework provides institutional administrators with a strategic diagnostic tool (see Table 4), helping them pinpoint their position within the two-dimensional matrix formed by “Resource Endowments” and “Industry Traction.” Consequently, the first step of reform shifts from blindly adopting external “best practices” to initiating change based on scientific self-positioning. This diagnostic outcome directly reveals the most suitable strategic pathway and the combination of mechanisms that need to be prioritized for cultivation.

5.3 Limitations and Future Research Directions

As an exploratory qualitative study, this research has some limitations, which also point the way for future research.

First, the cases in this study are concentrated primarily in Business Administration programs. Future research should apply this CMO framework to a wider range of disciplines (e.g., engineering, design) and conduct broader cross-regional comparisons to test and extend the theory’s generalizability.

Second, this study employs a cross-sectional design, which limits the ability to capture the dynamic evolution of collaborative relationships over time. Future research could adopt longitudinal case study methods to delve deeper into how trust is gradually built, how mechanisms evolve, and how organizations transition between different integration models.

Third, this study constructs a theoretical framework using qualitative methods. Building upon this foundation, future work could develop scales to measure the relevant constructs and employ large-scale surveys to quantitatively test the variable relationships proposed in the CMO framework, thereby achieving complementarity between qualitative findings and quantitative validation.

Finally, the core mechanisms identified in this study—Synergistic Governance and Curriculum Integration as a boundary object—likely have applicability beyond the specific context of industry-education integration. They may be relevant to any cross-sector collaboration scenario that requires bridging institutional logic boundaries (e.g., collaborations between NGOs and corporations, research partnerships between hospitals and universities, etc.). Future research could test the applicability of this study's core mechanisms and CMO configurational logic to other types of cross-organizational collaboration. This would significantly broaden the potential impact of this research and open up a more exciting research agenda.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Teaching Chinese as a Foreign Language: An Analysis of Modern Foreign Language Education Policy at Key Stage 2 in England

Tao Peng*

Chinese International Education College/ Overseas Education College, Xiamen University, Xiamen, China

*Corresponding author: Tao Peng, pengtao@xmu.edu.cn

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Abstract: This report critically examines the KS2 MFL under the policy of National Curriculum, with a particular focus on the teaching and implementation of Chinese as an MFL. It explores the function of the Office for Standards in Education, Children's Services and Skills (Ofsted) in ensuring responsibility for educational quality. By analyzing policy achievements and challenges, the report also draws on insights from a researcher's perspective on policy evaluation and an educator's hands-on experience in teaching Chinese. Recommendations are provided to address existing gaps, and highlight the importance of equal access, effective support systems, and better alignment between policy goals and classroom practices.

Keywords: Modern Foreign Language (MFL); Key Stage 2 (KS2); National Curriculum (NC); Ofsted; Mandarin Teaching and Learning as MFL

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1.Introduction

1.1 Research Background

There are notable disparities in foreign language education across England, with French, Spanish, German, Latin, and Chinese among the languages taught. Spanish leads in A-level enrollment, while Chinese reflects its growing popularity (British Council, Language Trends 2023). Language education is crucial for developing students' communication skills, cultural competence, and future career opportunities. In England, the National Curriculum (NC) mandates the teaching and learning of Modern Foreign Languages (MFL) for Key Stage 2 (KS2), highlighting its role in equipping students for participation in a globalized society.

1.2 Research Objectives

Smith (2000) introduced significant changes to language education in England. It expanded language options, emphasized the importance of language skills for future opportunities, and recommended starting language learning at age 7. Additionally, it proposed leadership initiatives to improve teaching quality. The introduction of mandatory foreign language learning at Key Stage 2 (KS2), targeting students from Year 3 to Year 6, reflects these recommendations and broader educational reforms. Under this policy, students are required to learn an ancient or modern foreign language, equipping them with essential skills for a globalized world.

The evolution of language education policies can be traced to the Plowden Report (1967), which championed a child-centered

approach. This philosophy emphasized creativity, personal development, and a broad curriculum, aligning with MFL's goals of fostering communication and cultural awareness. The report also stressed meeting individual learning needs, a concept central to differentiated strategies in MFL teaching. Furthermore, it highlighted challenges in teacher training and resources—issues that continue to affect the effective implementation of MFL at KS2.

The Plowden Report (1967) presents elements from a theoretical policy analysis framework, such as: Problem identification; Evidence-based policy making; Social equity; Implementation and monitoring.

2. From the Plowden Report era to the present

2.1 Key Terms

The National Curriculum has undergone significant changes since its inception. The Education Reform Act of 1988 laid the foundation, aiming to standardize education across England. Subsequent updates introduced a more inclusive and flexible approach, such as the inclusion of MFL at KS2. These changes reflect a growing emphasis on equipping students with practical skills and preparing them for a multicultural world.

Based on policy review, MFL at KS2 under the policy of National Curriculum (2013) has the goals and objectives:

1. Develop pupils' ability to communicate in a foreign language with confidence and fluency.
2. Foster an appreciation of different cultures and languages.
3. Build foundational skills for future language learning at Key Stage 3.

Key stakeholders include: Students, Teachers, Schools, Parents, Policy Maker, Media, etc.

Policy lever include: Legislation & Policy Documents; Teacher Training & Professional Development; Funding & Resource Allocation; Curriculum & Assessment; School Autonomy & Accountability: Ofsted.

Ofsted, established in 1992, was designed to improve educational standards and accountability in England. It was created to meet the government's and public's demand for strict oversight of educational quality. While Ofsted has played a crucial role in monitoring schools, its impact on MFL education at KS2 raises important questions.

The Education Inspection Framework (EIF) (2019) emphasizes the importance of cultural diversity and preparing students for a globalized world. These priorities align with MFL objectives at KS2, which aim to broaden students' horizons by exposing them to different cultures and ways of thinking. However, there is a gap between these aspirations and the reality in many schools.

2.2 Potential Conflicts

Although the curriculum guides teaching, contradictions may arise during the process of validating the National Curriculum's design through teaching practices. Taking the teaching of Mandarin as an MFL at KS2 as an example, in comparison with other European languages under the MFL framework, Joël Bellassen and Zhang Li (2008), in their study *New Concepts of the Common European Framework of Reference for Languages and Their Implications for Mandarin Teaching*, cite DeFrancis (1984), who argued that learning Chinese characters requires four times the effort of learning European languages.

2.2.1 Media and Literature Perspectives

The media has highlighted both successes and challenges in KS2 language education. Positive reports emphasize improved cultural awareness and communication skills, while criticisms focus on resource disparities and inconsistent teaching quality. Literature supports the policy's intent but questions its feasibility given teacher shortages and limited training opportunities (Johnson, 2013). Therefore, the MFL language learning outlined in the National Curriculum (NC) cannot adopt a one-size-fits-all approach to the number of instructional hours. Influenced by various external factors such as media, it is essential to strive for a case-by-case analysis to address specific issues effectively.

2.2.2 Ofsted's Role in MFL Education at KS2

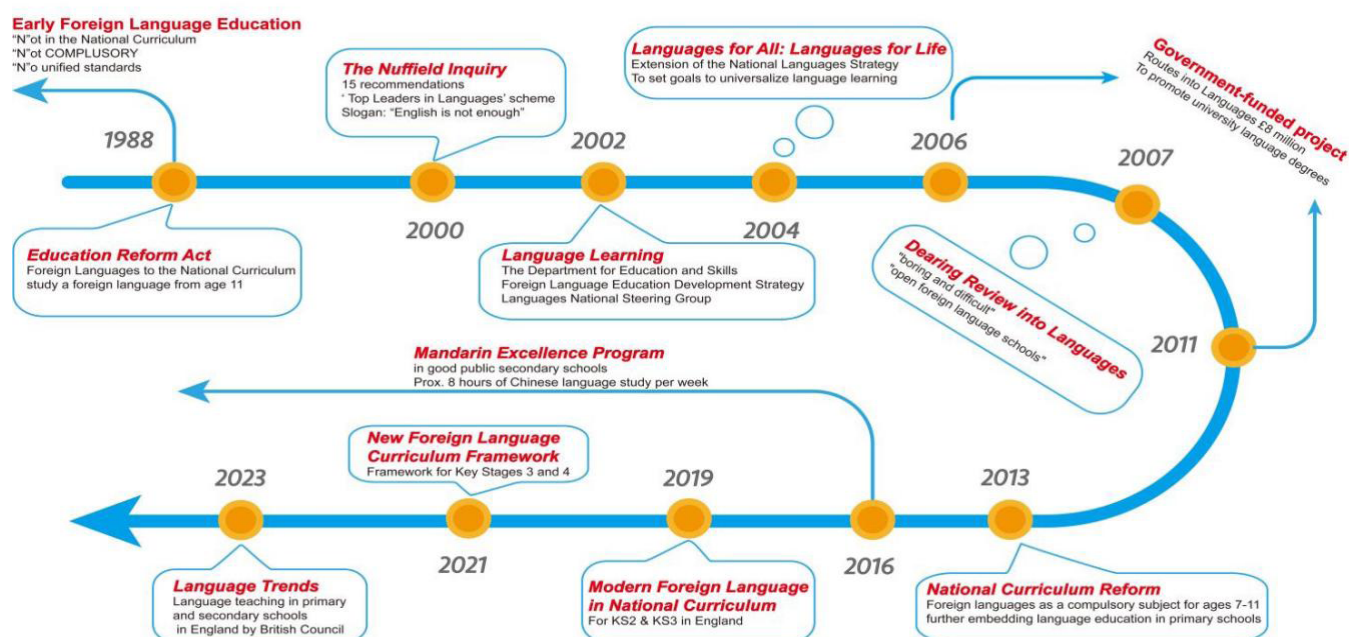
Ofsted has undoubtedly played a key role in holding schools accountable for educational quality. However, when it comes to MFL education at KS2, its emphasis on compliance and measurable outcomes risks undermining the broader cultural and global aims of the curriculum. To truly support MFL, Ofsted must adapt its inspection criteria to focus on meaningful learning experiences, address systemic challenges, and ensure that schools are equipped to meet both practical and aspirational goals.

Without these changes, Ball, S. J. (2003) indicates MFL risks becoming another tick-box exercise rather than a transformative part of the KS2 curriculum.

By examining the historical development of educational policies and the evolution of the National Curriculum, reporter will highlight the increasing importance and challenge of MFL teaching.

3. Development of National Curriculum Policy: Focus on KS2

Figure 1 The Historical Development of National Curriculum in England (by Author's Own)



Historically, the Education Reform Act (1988) included foreign languages in the National Curriculum, starting from age 11 (Key Stage 3). However, language learning was not compulsory and lacked unified standards, leaving younger learners without structured exposure.

3.1 Key Changes for MFL at KS2

The most significant shift occurred with the 2016 National Curriculum Reform (2016), which made foreign languages compulsory for ages 7–11 (KS2). This reform aimed to embed language education in primary schools, ensuring students develop foundational language skills early. It aligned with broader goals to increase language proficiency and global awareness among students.

3.2 Strategic Efforts

Prior to this reform, initiatives such as the 2002 National Languages Strategy (2002) and the 2004 Language Learning Strategy (2004) highlighted the importance of earlier language exposure but lacked enforceable policies for KS2. The 2016 reform (2016) addressed this gap, focusing on fostering speaking, listening, reading, and writing skills in a foreign language.

Figure3: Comparison of LeBron James and Michael Jordan's scoring ability in different position.

3.3 Recent Developments

Post-2016, the emphasis on early language learning was reinforced by programs like the Mandarin Excellence Program (2023), which highlights the importance of introducing global languages at an early age.

4. Policy Impact on MFL Education at KS2

Making foreign languages compulsory at KS2 has ensured that students are better prepared for language learning at Key Stage 3. This early start provides a stronger foundation, contributing to improved proficiency and engagement in later education stages.

Figure 2 Languages Programmes of Study: KS2 NC in England (Department for Education, 2019)

Department
for Education

Languages programmes of study: key stage 2

National curriculum in England

Purpose of study

Learning a foreign language is a liberation from insularity and provides an opening to other cultures. A high-quality languages education should foster pupils' curiosity and deepen their understanding of the world. The teaching should enable pupils to express their ideas and thoughts in another language and to understand and respond to its speakers, both in speech and in writing. It should also provide opportunities for them to communicate for practical purposes, learn new ways of thinking and read great literature in the original language. Language teaching should provide the foundation for learning further languages, equipping pupils to study and work in other countries.

Aims

The national curriculum for languages aims to ensure that all pupils:

- understand and respond to spoken and written language from a variety of authentic sources
- speak with increasing confidence, fluency and spontaneity, finding ways of communicating what they want to say, including through discussion and asking questions, and continually improving the accuracy of their pronunciation and intonation
- can write at varying length, for different purposes and audiences, using the variety of grammatical structures that they have learnt
- discover and develop an appreciation of a range of writing in the language studied.

Attainment targets

By the end of each key stage, pupils are expected to know, apply and understand the matters, skills and processes specified in the relevant programme of study.

Schools are not required by law to teach the example content in [square brackets].

Published: September 2013

Figure 3 Languages Programmes of Study: KS2 NC in England (Department for Education, 2019)

Key stage 2: Foreign language

Teaching may be of any modern or ancient foreign language and should focus on enabling pupils to make substantial progress in one language. The teaching should provide an appropriate balance of spoken and written language and should lay the foundations for further foreign language teaching at key stage 3. It should enable pupils to understand and communicate ideas, facts and feelings in speech and writing, focused on familiar and routine matters, using their knowledge of phonology, grammatical structures and vocabulary.

The focus of study in modern languages will be on practical communication. If an ancient language is chosen, the focus will be to provide a linguistic foundation for reading comprehension and an appreciation of classical civilisation. Pupils studying ancient languages may take part in simple oral exchanges, while discussion of what they read will be conducted in English. A linguistic foundation in ancient languages may support the study of modern languages at key stage 3.

Pupils should be taught to:

- listen attentively to spoken language and show understanding by joining in and responding
- explore the patterns and sounds of language through songs and rhymes and link the spelling, sound and meaning of words
- engage in conversations; ask and answer questions; express opinions and respond to those of others; seek clarification and help*
- speak in sentences, using familiar vocabulary, phrases and basic language structures
- develop accurate pronunciation and intonation so that others understand when they are reading aloud or using familiar words and phrases*
- present ideas and information orally to a range of audiences*
- read carefully and show understanding of words, phrases and simple writing
- appreciate stories, songs, poems and rhymes in the language
- broaden their vocabulary and develop their ability to understand new words that are introduced into familiar written material, including through using a dictionary
- write phrases from memory, and adapt these to create new sentences, to express ideas clearly
- describe people, places, things and actions orally* and in writing
- understand basic grammar appropriate to the language being studied, including (where relevant): feminine, masculine and neuter forms and the conjugation of high-frequency verbs; key features and patterns of the language; how to apply these, for instance, to build sentences; and how these differ from or are similar to English

The starred (*) content above will not be applicable to ancient languages.

4.1 The Goal of a Broad and Balanced Curriculum

The NC emphasizes a broad and balanced approach, including subjects like MFL to ensure students' holistic development. At KS 2, MFL is intended to enrich students' learning, spark curiosity, and develop communication skills that go beyond their immediate surroundings. However, while the policy's intentions are commendable, its execution raises questions. Is this inclusion truly fostering these skills, or is it merely a superficial addition to meet policy goals? Without sufficient resources or well-trained teachers, this ambition may fail to deliver meaningful outcomes.

4.2 Questioning the Quality of Language Education

The NC framework claims to evaluate the quality of language education by focusing on building "cultural capital" through effective teaching methods and curriculum design. At KS 2, MFL policies should align with Ofsted's standards for high-quality education, emphasizing communication skills and cultural understanding. Yet, the reality often falls short. Many schools face challenges like insufficient teacher training, lack of time allocated to MFL lessons, and inadequate integration with other subjects. These gaps raise doubts about whether the policy genuinely achieves the high-quality education it promises.

4.3 Insights into Mandarin Teaching as an MFL

The British Chinese Language Teaching Society (2013) highlights that reaching A1 proficiency in Mandarin (excluding characters) requires 100–150 hours, while B1 proficiency demands around 1,000 hours. Based on my experience as a KS2 Mandarin teacher, it is evident that Mandarin teaching in schools often fails to align with the National Curriculum. To strengthen Mandarin as a Modern Foreign Language (MFL), several improvements are necessary.

4.3.1 Adjusting Time Allocation

Mandarin lessons need a greater time commitment. Currently, insufficient weekly hours hinder students' ability to practice foundational skills like tones and basic structures. Scheduling at least two hours of Mandarin weekly is essential.

4.3.2 Balancing Element Teaching

Yang (2018) demonstrates that Pinyin, which is regarded as Mandarin pronunciation guide system, plays a crucial role in facilitating early-stage Mandarin learning for beginners, offering a systematic way to connect pronunciation with meaning. However, the language coordinator from my school did not endorse teaching pinyin to students and has instructed me to exclude Pinyin instruction from the beginning of KS1, as Table 1 shows. This approach contradicts the National Curriculum, which emphasizes the importance of exploring language patterns and sounds through songs and rhymes, as well as connecting spelling, pronunciation, and meaning, will have side-effect for the teaching and learning at KS2.

4.3.3 Professional Development for Mandarin Teachers

Cai (2017) discusses the importance of professional development for Mandarin teachers, particularly for those dispatched from China to teach in England. Many visiting teachers struggle to adapt to the unique demands of KS2 education, including the integration of Mandarin into the broader curriculum and the pedagogical approaches used in English schools.

Even as a visiting teacher who teach Chinese Mandarin, participating in school initiatives such as INSET (In-Service Education and Training) days is essential. These sessions provide valuable insights into school-specific strategies, classroom management techniques, and ways to align Mandarin teaching with the expectations of the National Curriculum.

4.3.4 Others

Additionally, integrating MFL into other subjects, such as teaching basic math or geography concepts in Mandarin, can enhance its relevance and provide practical applications.

5. Implementation

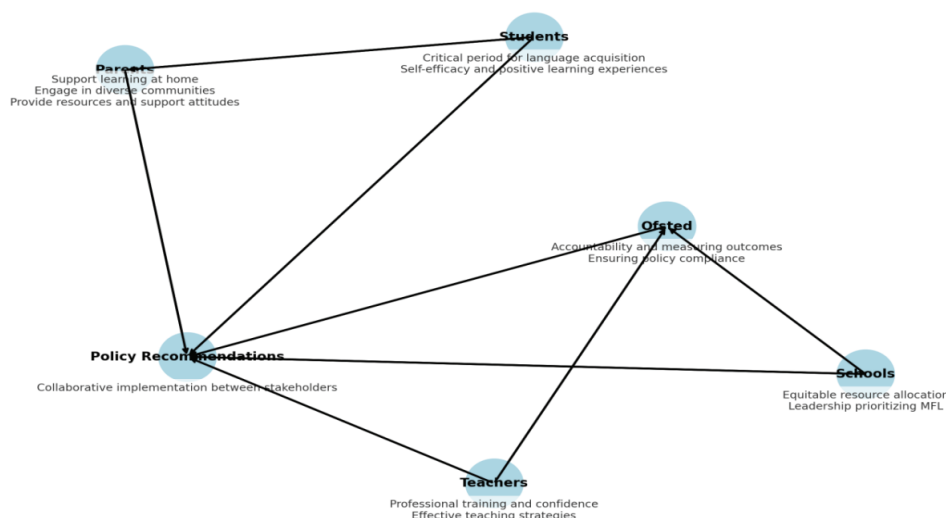
The implementation of policy on MFL at KS2 faces several practical challenges. While the policy aims to essential language skills—such as practical communication, vocabulary building, grammar understanding, and cultural appreciation—it often lacks the necessary support to achieve these goals. As mentioned in the previous chapter 4, the time allocated to MFL at KS2 is often insufficient for students to develop meaningful proficiency. Furthermore, the reliance on generalist primary school teachers—many of whom lack specialized language training—limits the effectiveness of instruction. Although the policy was introduced to address the UK's low language proficiency levels and align with global standards, its success is hindered by

these barriers.

Hattie (2008) and the research framework emphasizes the multi-dimensional factors influencing educational achievement, including contributions from students, families, schools, and teachers. Understanding these stakeholder perspectives is essential for addressing MFL policy challenges.

5.1 Implementation of Policy on MFL at KS2

Figure 4 Implementation of Policy on MFL at KS2 (by Author's own)



5.1.1 Stakeholder Perspectives: Students

Hattie (2008) highlights the importance of age and developmental stages in learning capacity. KS2 (ages 7–11) represents a critical period for language acquisition, making it an ideal stage to introduce MFL. During this stage, students' cognitive flexibility allows them to grasp new languages more easily. Learning a foreign language improves their communication skills, builds confidence, and opens up future opportunities. It also fosters cultural understanding, helping students connect with people from different backgrounds and preparing them for a globalized world. (Especially exposure to Chinese language and culture broadens students' horizons, encouraging curiosity and tolerance.)

5.1.2 Stakeholder Perspectives: Teachers

Teachers design lessons, explain concepts, and guide students through the process of learning a new language. Teachers also motivate students to practice speaking, reading, and writing. However, the lack of specialized training for many primary school teachers can significantly impact the quality of MFL instruction. Teachers' expertise and commitment are critical to ensuring effective language education. (Based on dual roles as a researcher and a KS2 Mandarin teacher, I observe that Mandarin teaching in a primary school does not fully align with the NC. Professional development programs can equip teachers with the skills to teach Mandarin or other MFL effectively.)

5.1.3 Stakeholder Perspectives: Schools

Schools provide the environment and resources needed for MFL education. They ensure that students have access to suitable materials, such as textbooks, digital tools, and audio resources. Schools also play an important role in organizing professional development opportunities for teachers, equipping them with the skills to deliver high-quality lessons. Additionally, schools are responsible for setting achievable goals and monitoring student progress, helping to maintain high standards in language learning. (Introducing Chinese calligraphy clubs, Kungfu classes, or other Chinese cultural workshop can enrich the MFL learning experience.)

5.1.4 Stakeholder Perspectives: Parents

Parents provide essential support for their children's language learning. They encourage regular practice at home, take an interest in their child's progress, and create a positive learning atmosphere. In linguistically diverse communities, parents can also share their own language skills, helping to build stronger connections to the new language. This support boosts students' confidence and motivation to engage with MFL learning. Schools can provide parents with user-friendly resources like apps

or activity sheets to reinforce learning at home.

5.2 Ofsted Role and Accountability

Ofsted, plays a crucial role in evaluating schools' adherence to the KS2 MFL curriculum. Inspection reports focus on teaching quality, student outcomes, and curriculum delivery. However, critics argue that Ofsted's emphasis on measurable outcomes may overshadow the broader goals of cultural appreciation and communication, highlight areas where MFL policy and practice may fall short of Ofsted's expectations, offering recommendations for improvement.

So it is important to examine how MFL policies at Key Stage 2 reflect Ofsted's cultural capital priorities and analyze whether current MFL practices effectively broaden students' horizons and meet Ofsted's standards.

Table 2 KS2 Language Education Mentioned in Ofsted Inspect Report (Ofsted Inspect Report, 2023)

Aspect	Primary School	Secondary School
Statutory Language Requirement	Modern or ancient language required from age 7 (from Year 3).	Language required in Key Stage 3; optional in Key Stage 4 (GCSE).
Primary Challenges	Time allocation for languages, teacher training and curriculum planning.	Motivating students, ensuring curriculum continuity, increasing GCSE participation.
Secondary Challenges	Weak communication with secondary schools during transition.	Challenges in sustaining language study post-14 due to optional status.
Focus of Language Curriculum	Building foundational skills and exposure to one language.	Developing fluency, grammar, and cultural understanding.
Common Issues	Inconsistent progress due to variable language time in Year 6.	Declining participation in languages at GCSE and A-Level.
Examples of Languages Offered	Common options include French, Spanish, or German.	French, Spanish, German; some offer Chinese, Italian, or Latin.

6.Challenges and Barriers

Ko J.& Sammons P. (2013) discuss aspects relevant to MFL, especially within the context of KS2. They stress the importance of providing KS2 teachers with robust training and resources for MFL instruction, especially since many primary school teachers may lack confidence or proficiency in foreign languages. They call for clear government policies to promote MFL learning at KS2, including curriculum guidance, resources, and assessment frameworks to ensure consistent delivery across schools.

6.1 Teacher Training

Reflecting on challenges in policy implementation, a lack of qualified language teachers limits effective curriculum delivery, teacher training, and resource allocation that persist from the Plowden era to the present.

6.2 Resource Allocation

Schools in economically disadvantaged areas face difficulties accessing resources and support. Ofsted stresses accountability in delivering policies that meet educational goals, including MFL at KS2.

Challenges such as teacher training, resource allocation, and curriculum design in MFL policy can be evaluated against Ofsted's criteria, examining whether these efforts are sufficient to meet the NC's goals of cultural capital and curriculum breadth.

6.3 Others

There is no standardized assessment for MFL at KS2, creating variability in student outcomes. And it is very important to engage parents, particularly those from linguistically diverse backgrounds, remains a challenge.

7.Recommendations

7.1 Enhanced Teacher Training

It is significant to provide specialized training programs to equip teachers with the skills needed to deliver high-quality language education. Teacher incentives include grants aimed at encouraging individuals to train as MFL language teachers, particularly in English-medium schools, where there is a shortage of qualified staff. For instance, Chinese teachers are encouraged to join school INSET training, which can learn how to incorporate Mandarin into thematic projects or design engaging activities that resonate with KS2 learners. This ensures that Mandarin teachers are not isolated from the school community but are instead active contributors to students' overall education.

7.2 Multi-Position Versatility

Funding could be increased for language programs, particularly in under-resourced schools. Continue to cooperate with public and private companies. Continuously improve the quality and expand the scope of online education and learning materials. Carry out cooperation between different regions and establish virtual language communities across the country.

7.3 Others

A national framework will be introduced for assessing MFL proficiency at KS2 to ensure consistency and accountability.

Strategies can be developed to involve parents, such as workshops and multilingual resources. Parents are encouraged to try user-friendly resources like apps or activity to help learning with KS2 pupils at home.

Students would be encouraged to pursue language studies beyond KS2 through incentives and curriculum integration.

Conclusion

The MFL policy aims to prepare students for global engagement and improve the UK's international education standing. However, the current approach does not seem to be fully aligned with these goals. Local Education Authorities (LEAs) should coordinate foreign language learning programs in primary schools to ensure that every student in the KS2 stage has the opportunity to learn at least one foreign language.

The policy often emphasizes breadth over depth, leaving students with fragmented knowledge rather than practical language skills and insufficient time to build a coherent knowledge system. For a national education policy aimed at meeting standards, there is still room for improvement.

The KS2 MFL policy represents a significant step toward fostering language skills and cultural awareness among young learners. While its goals align with national and international priorities, challenges such as teacher shortages, resource disparities, and inconsistent implementation hinder its success. Addressing these barriers through targeted interventions will enhance the policy's effectiveness and ensure equitable language education for all students. Future research should explore long-term impacts and ways to sustain student interest in language learning.

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Transforming Clinical Skills Teaching with a Flipped Classroom and Problem-Based Learning Hybrid Approach

Juntong Liu*

Teaching Experiment Center, Liaoning University of Traditional Chinese Medicine, Shenyang, 110847, China

*Corresponding author: Juntong Liu, wojiaoliujuntong@163.com

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Abstract: The enhancement of clinical skills teaching quality is pivotal for cultivating competent medical professionals. Confronting the limitations of traditional lecture-based methods in fostering student initiative and clinical reasoning, this study proposes and explores a novel multidimensional interaction model that integrates the Flipped Classroom (FC) and Problem-Based Learning (PBL) approaches. The model is structured around three core phases: pre-class knowledge acquisition via digital platforms, in-class PBL sessions for knowledge internalization and clinical application, and post-class reflection and consolidation. This framework facilitates a fundamental shift in educational roles, positioning the teacher as a guide and the student as an active learner. Preliminary application within a clinical skills course demonstrates that the model effectively stimulates student engagement, improves autonomous learning capabilities, strengthens teamwork and communication skills, and deepens the integration of professional values and ethical practice. This FC-PBL integrated model presents a viable and effective pathway for innovating clinical skills training in medical education.

Keywords: Flipped Classroom; Problem-Based Learning; Clinical Skills; Teaching Reform; Medical Education; Interactive Learning

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1.Introduction

Clinical skills training represents a crucial bridge between theoretical knowledge and practical application, serving as the cornerstone for producing clinically competent medical graduates^[1]. In China, the ongoing expansion of higher education necessitates a heightened focus on teaching quality, demanding a shift from passive, teacher-centered instruction to more engaging and effective pedagogical models^[2]. The traditional “cramming” method often relegates students to a passive role, which can stifle the development of critical thinking, innovation, and practical problem-solving abilities essential for modern healthcare^[3].

In this context, the integration of innovative educational strategies offers significant promise. The Flipped Classroom (FC) model, which leverages digital resources to transfer initial knowledge acquisition outside the classroom, frees up valuable in-class time for active learning^[4]. Concurrently, Problem-Based Learning (PBL), a well-established student-centered pedagogy, uses real-world clinical problems as a stimulus for learning, effectively promoting self-directed study, clinical reasoning, and collaborative skills^[5]. While both FC and PBL have demonstrated individual merits, their integration is theoretically synergistic. FC provides the foundational knowledge framework, while PBL offers a dynamic environment for its application, thereby effectively narrowing the theory-practice gap^[6, 7]. This study, grounded in the teaching practices of the “Clinical

Basic Skills of Traditional Chinese and Western Medicine” course, constructs a multidimensional interaction model that systematically integrates FC and PBL, and investigates its implementation pathway and impact on clinical skills teaching quality.

2.The Theoretical Rationale and Value of the FC-PBL Integrated Model

2.1 Facilitating a Pedagogical Shift to Empower Learners

The integrated model fundamentally redefines the roles of instructors and students. In the pre-class phase, students transition from passive recipients to active constructors of knowledge by engaging with curated digital learning materials^[8]. During class, instructors shed their traditional role as sole knowledge authorities and become facilitators of learning, guiding PBL discussions and clinical simulations. This shift empowers students, placing them at the center of the learning process and fully mobilizing their subjective initiative^[9].

2.2 Promoting Deep Learning and Clinical Competence

The model creates a continuous learning cycle that promotes deep knowledge internalization. The FC component ensures students acquire essential knowledge independently, while the in-class PBL sessions challenge them to apply, analyze, and synthesize this knowledge in solving complex, authentic clinical problems^[10]. This progression from knowledge acquisition to application effectively bridges the gap between abstract theory and clinical practice, thereby enhancing students’ clinical problem-solving capabilities^[11].

2.3 Embedding Professional Values and Ethical Formation

The model provides a robust framework for seamlessly integrating “Curriculum Ideology and Politics.” By systematically embedding elements of medical ethics, humanitarian spirit, and professional responsibility into clinical cases and discussions, the model fosters the development of virtuous, well-rounded medical professionals^[12]. Cultivating a spirit of collaboration, empathy, and dedication within the PBL team environment aligns with the overarching goal of fostering virtue through education^[13].

3.Construction and Implementation of the FC-PBL Multidimensional Interaction Model

The proposed model operationalizes the integration of FC and PBL through a structured, three-phase implementation pathway.

3.1 Pre-class Phase: Platform Construction and Preparatory Work

3.1.1 Resource Integration and Digital Platform Development

A robust and user-friendly online teaching platform is the foundational infrastructure for the FC model^[14]. Building upon existing course resources, we developed a comprehensive digital repository featuring micro-lectures, supplementary readings, clinical case vignettes (“micro-cases”), and self-assessment quizzes. This platform also incorporates interactive features such as discussion forums and online Q&A to support collaborative pre-class learning and timely feedback^[8].

3.1.2 Faculty Development and Readiness

Successful implementation requires teachers to be proficient in both FC and PBL methodologies. Targeted training workshops were conducted to equip faculty with the skills needed for creating high-quality digital content, designing compelling PBL cases, and effectively facilitating student-centered discussions. This preparation is critical for ensuring a smooth transition from traditional instruction^[15].

3.2 In-class Phase: Clinical Application and Value Guidance

3.2.1 Problem-Based Learning and Clinical Simulation

Classroom time is primarily dedicated to active, collaborative learning through PBL. Faculty present students with carefully designed, realistic clinical scenarios. Working in small groups, students engage in case analysis, differential diagnosis, and development of management plans. This process rigorously exercises their clinical reasoning, communication, and teamwork skills^[16]. For instance, a simulated “acute abdominal pain” consultation allows students to practice history-taking, physical examination maneuvers, and interprofessional collaboration.

3.2.2 Integration of Ideological and Political Education

The PBL process naturally incorporates professional value cultivation. Discussions around patient confidentiality, informed consent, and ethical dilemmas in clinical care are guided by the instructor. This integrates the development of technical skills with the formation of a strong professional ethical foundation, emphasizing the duty of care and compassion^[17].

3.3 Post-class Phase: Consolidation and Continuous Improvement

3.3.1 Reinforcement and Personalized Feedback

Following the in-class session, instructors provide structured feedback on both individual and group performance, highlighting strengths and identifying areas for improvement. Key learning points, exemplary group solutions, and additional resources are consolidated and shared on the online platform to aid in knowledge reinforcement and self-directed review^[18].

3.3.2 Reflective Practice and Curriculum Optimization

The model establishes a feedback loop for continuous quality enhancement. Instructors analyze data from platform analytics, student performance on assessments, and collected feedback to identify challenges and successes. This reflective practice informs subsequent iterations of course design, PBL cases, and instructional strategies, leading to sustained improvement in teaching effectiveness^[19].

4. Practical Challenges and Strategic Countermeasures

The implementation of this innovative model is not without its challenges, which require proactive strategies.

4.1 Faculty-Related Challenges: Capacity Building and Workload Management

The model demands higher levels of digital literacy, case design expertise, and facilitation skills from teachers, which can be a barrier for some^[20]. Furthermore, the initial development of digital resources and the ongoing facilitation of PBL sessions can increase faculty workload^[21].

Countermeasures: Institutions should invest in sustained, practical faculty development programs and foster communities of practice for sharing resources and experiences. Furthermore, formal recognition of teaching innovation in promotion and performance appraisal systems is essential to incentivize faculty engagement.

4.2 Student-Related Challenges: Readiness and Adaptation

Students may exhibit varying levels of self-discipline and digital competency, leading to uneven pre-class preparation. Some may initially struggle with the active learning demands of PBL after years of passive learning^[22].

Countermeasures: Clear guidelines and scaffolding for autonomous learning should be provided. Tiered task design can cater to diverse student abilities. Early and transparent communication about the rationale and expectations of the new model is crucial to foster student buy-in and a smooth transition.

5. Conclusion and Future Directions

The FC-PBL integrated multidimensional interaction model represents a significant shift towards a student-centered, competency-based paradigm in clinical skills education. By systematically restructuring the learning process across pre-class, in-class, and post-class phases, it effectively promotes deep learning, clinical competency, and professional identity formation. Initial implementation suggests its potential to enhance student engagement, autonomous learning capacity, and collaborative skills.

Future work will focus on the long-term evaluation of the model's impact, including tracking graduates' clinical performance. Further development of the digital platform, particularly incorporating learning analytics and AI-assisted personalized feedback, is also a key direction. This model offers a valuable reference for ongoing reform and innovation in medical and health professions education.

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The Development History, Typology, and Current Challenges of Skill-Oriented Universities

Huayang Zhang*

School of Digital Media, Shenzhen Polytechnic University, Shenzhen, 518055, China

*Corresponding author: Huayang Zhang, zhanghuay@szpu.edu.cn

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Abstract: Amid the global trend of the digital-intelligent economy and industrial transformation, skill-oriented universities have emerged as a crucial force driving urban innovation and development. With the evolution of new-generation information technologies, strategic emerging industries, such as artificial intelligence, integrated circuits, and intelligent connected vehicles, are witnessing exponential growth in their demand for highly skilled technical talent. However, traditional models of skills training continue to face deep-rooted challenges, including misalignment between academic disciplines and industry needs, fragmented university-enterprise collaboration in talent development, and insufficient integration of digital and intelligent technologies. By examining the development trajectory, classification, and existing issues of skill-oriented universities, this study provides a systematic analysis of their transformation and upgrading, with the aim of offering theoretical insights and practical references for cultivating world-class talent in technical and vocational fields.

Keywords: Skill-Oriented Universities; Development History; Typology; Current Challenges

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1.Introduction

In the context of the global shift toward a digital-intelligent economy and smart industrial transformation, skill-oriented universities have become a key engine for urban innovation and development. As new-generation information technology continues to advance, strategic emerging industries, including artificial intelligence, integrated circuits, and intelligent connected vehicles, are experiencing rapidly growing demand for high-level technical talent. In January 2025, the Central Committee of the Communist Party of China and the State Council issued the “Education Modernization Plan (2024 - 2035),” which, for the first time, introduced the concept of skill-oriented universities, offering a more refined classification framework for higher vocational education. The plan also proposed establishing vocational-technical programs within application-oriented undergraduate institutions, promoting integration between vocational and general education to expand students’ pathways for growth and success. This reflects the increasing importance of higher vocational education. Clear definitions and classifications have laid a solid foundation for accelerating high-quality development in this sector. At the same time, skill-oriented universities must explore a distinctive path for transformation and in-depth development one that sets them apart from traditional research-oriented and application-oriented institutions through unique innovation and defining features.

As a critical link between the education system and industrial ecosystems, the transformation and upgrading of skill-oriented universities not only contribute to enhancing urban competitiveness but also carry the strategic mission of overcoming

“bottleneck” technological constraints and achieving self-reliance in key sectors. Nevertheless, in practice, traditional talent training models still encounter deep-seated issues, such as the mismatch between academic programs and industry requirements, challenges in university-enterprise collaborative education, and a lack of digital and intelligent technologies. These constraints hinder the precise alignment of talent supply with industrial demands. Although current efforts have yielded notable results, development bottlenecks persist in various areas, including the slow adaptation of academic programs to industrial changes, weak university-enterprise collaboration, and inadequate integration of digital intelligence.

2. Historical Development of Skill-Oriented Universities

2.1 Evolution of Skill-Oriented Universities

The development of skill-oriented universities in China can be divided into five distinct phases. The first phase, the emergence of industrial education, spanned approximately from 1860 to 1911. The earliest form of skill-oriented institutions can be traced back to the Westernization Movement in the mid-19th century. In 1868, Zuo Zongtang and Shen Baozhen established the “Art Garden” within the Fuzhou Shipbuilding Academy, which comprised an apprentice workshop (training intermediate technicians) and a master craftsmen school (training advanced technicians). This marked China’s first technical school. Its integrated model of “combining factory and school, merging work and learning” laid the practical foundation for modern skill-based education. Students participated in the production of milestone achievements such as China’s first thousand-ton steamship and the first steam engine.

The second phase, the exploration of modern vocational education, lasted from 1912 to 1949. In the early 20th century, industrialist Zhang Jian founded the Textile and Dyeing Training Institute (1912) and the Women’s Craft Training Institute (1914) in Nantong, Jiangsu, integrating technical training with production, a model later known as the “Nantong Model.” In 1918, Huang Yanpei established the China Vocational School in Shanghai, advocating the educational philosophy of “using both hand and brain, integrating learning and practice.” Through a work-study model, the school trained technicians in fields such as metalwork and carpentry, earning recognition as a pioneer in Chinese vocational education. In 1942, New Zealand friend Rewi Alley founded the Bailie Vocational School in the Shaanxi-Gansu-Ningxia Border Region, adopting a work-study approach to train mechanical maintenance and manufacturing talents, making it a key representative of vocational education in China’s revolutionary base areas. Meanwhile, technical schools such as the Dalian Railway Factory Youth Technical School (1946) were established in the Northeast Liberated Area, laying the technical groundwork for New China’s industrialization.

The third phase, the introduction of the Soviet model, extended from 1950 to 1977. In the 1950s, with the implementation of the First Five-Year Plan, China adopted the Soviet model to establish a technical school system. Institutions such as the Beijing Experimental Technical School (1955) were founded to train technical workers in fields like mechanical manufacturing and mining. By 1957, the country had 144 technical schools with over 60,000 students. By 1965, the number of technical schools had increased to 740, with 280,000 students, forming a backbone of technical talent supporting socialist construction.

The fourth phase, the revival and restructuring of vocational education, spanned from 1978 to 2013. The 1980 “Report on the Reform of Secondary Education Structure” proposed the policy of “promoting both general education and vocational education,” leading to the gradual restoration of technical schools. The establishment of Tianjin Vocational University in 1978 marked the beginning of higher vocational education. The 1985 “Decision on the Reform of the Education System” by the Central Committee of the Communist Party of China first proposed the “establishment of a vocational education system,” accelerating the development of vocational universities. By 1999, before the implementation of the college expansion policy, China had over 120 vocational universities. The promulgation of the “Vocational Education Law” in 1996 legally affirmed the status of vocational education for the first time, clarifying the developmental framework for technical schools, vocational secondary schools, and higher vocational institutions. After the college expansion in 1999, higher vocational education entered a period of rapid growth. Starting in 2005, the national “school-enterprise cooperation, work-integrated learning” model was promoted. Post-2010, WorldSkills Competition standards were incorporated into teaching outcomes, with students from technical colleges winning international awards in fields such as CNC machining and welding, facilitating the alignment

of teaching standards with global benchmarks.

The fifth phase, the transition to application-oriented education and global alignment, began around 2014 and extends to 2025. The 2014 State Council “Decision on Accelerating the Development of Modern Vocational Education” proposed “guiding some undergraduate institutions to transition into application-oriented universities.” By 2020, 633 application-oriented undergraduate institutions had passed industry-education integration evaluations, with Nanjing Institute of Industry Technology becoming one of the first pilot institutions for vocational undergraduate education. The 2021 revision of the “Vocational Education Law” explicitly affirmed the “equal importance” of vocational education and general education. Institutions such as Shenzhen Polytechnic University began offering vocational undergraduate programs, establishing a continuous training system spanning secondary vocational education, higher vocational education, and vocational undergraduate education. Subsequently, Shenzhen implemented the “city-industry-education consortium” system, dynamically adjusting program offerings to align with the “20+8” industrial clusters (e.g., artificial intelligence, integrated circuits), reducing the program adjustment cycle to nine months.

Looking ahead, skill-oriented universities will enter a phase of high-speed development empowered by new-quality productive forces. Post-2025, these institutions will focus on addressing “bottleneck” technologies, promoting self-reliance in skill certification standards, and leveraging virtual simulation teaching systems to enhance educational equity and skill accessibility. They will further deepen intelligent and innovative teaching models, promote the “Shenzhen Model” vocational education evaluation system, and contribute to poverty alleviation through skills development and industrial upgrading.

2.2 The Development History of Skill-Oriented Universities Abroad

The development of skill-oriented universities abroad can be divided into five main stages. The first stage, the origin of skill-oriented universities, dates back to the Industrial Revolution in the 19th century. Early models were represented by Germany’s “dual system,” which emphasized school-enterprise cooperation in training technical workers. Its prototype can be traced back to the medieval guild system, where apprentices were trained through a three-tier system of “apprentice, journeyman, master.” The promulgation of the *Handwerksordnung* (Craft Trades Regulation) in 1897 established the modern dual system, where students alternate between learning in enterprises (practical training) and vocational schools (theoretical education), forming a “technology-education-enterprise” symbiotic network. By the late 19th to early 20th century, Germany’s dual system had gradually matured.

The second stage, post-war reconstruction and system refinement, spanned approximately from 1950 to 1970. The enactment of the *Berufsbildungsgesetz* (Vocational Training Act) in 1969 marked the maturation of Germany’s dual system, establishing a tripartite collaboration mechanism involving enterprises, schools, and trade associations. The act defined 450 occupational training categories and introduced the IHK (Industrie- und Handelskammer) certification system, achieving skill standardization. For example, traditional apprenticeships for fitters in the automotive industry were phased out, while training for high-skilled positions such as CNC machine operation became mainstream. By the 1970s, Germany’s youth unemployment rate remained relatively low. Influenced by the Percy Report and the White Paper on Technical Education, the UK upgraded ten institutions, including the Birmingham College of Technology, to higher technical colleges in 1956, which evolved into 30 polytechnics by 1972. The Education Reform Act of 1988 granted them equal status with universities, focusing on cultivating practical talents in fields such as engineering and information technology. In the 1950s, the Truman administration promoted the development of the community college system, leading to a rapid increase in the number of community colleges and students. The “2+2” model (two years of vocational education followed by two years of academic education) became a model for mass education. For instance, California community colleges collaborated with Silicon Valley enterprises to develop semiconductor technology courses.

The third stage, globalization and deepened integration of industry and education, spanned roughly from 1980 to 2000. Germany’s dual system was recognized by the European Union as a pillar of vocational education for member states. In the 1990s, countries such as China and Brazil introduced the “school-enterprise dual-subject” model. For example, some vocational colleges in China established “factories within schools,” though the depth of enterprise participation remained insufficient. In 1992, Singapore’s Nanyang Polytechnic pioneered the “Teaching Factory” model, embedding enterprise

production lines into the campus, allowing students to directly participate in Philips' electronic component production projects. This model enhanced graduates' employability and was later promoted to ASEAN countries. In the 1990s, Australia established the "Training Packages" system, led by industry associations, which defined competency standards for over 400 occupations.

The fourth stage, digital transformation and response to new business models, spanned approximately from 2001 to 2020. The Technical University of Munich collaborated with Siemens to establish an Industry 4.0 laboratory, developing a "digital twin teaching system" that enabled students to master smart production line management skills through virtual simulation training. In 2019, the IHK added 12 emerging occupational certifications, including AI operations and maintenance and blockchain applications. In 2015, the United States enacted the STEM Education Act, promoting the introduction of courses such as drone operation and 3D printing in community colleges. Tesla partnered with Texas State Technical College to establish a "Gigafactory Training Base," where students participated in battery production line debugging, reducing the training cycle to six months. In France, the Grandes Écoles underwent reforms. In 2018, École Polytechnique partnered with Airbus Group to establish a joint research center for aerospace digital twins, where students participated in developing algorithms for predicting aircraft engine failures, with some research outcomes directly translated into corporate patents.

The fifth stage, new-quality productive forces and global governance, began around 2021 and continues to the present. In 2023, Germany launched the "Dual Vocational Education Export Initiative," establishing 15 inter-enterprise training centers in India and Mexico to export IHK certification standards. For example, BMW's Leipzig plant used this system to train local talent in high-voltage electronic control technology for new energy vehicles, enhancing local production rates. In 2024, Singapore established the world's first "Metaverse Skill Certification Platform," collaborating with NVIDIA to develop a virtual reality training system. Students can simulate the operation of chip lithography machines, reducing error rates compared to traditional teaching methods. The 2025 BRICS Skill Standard Mutual Recognition Agreement covers 28 fields, including industrial robotics and biopharmaceuticals. Shenzhen Polytechnic University collaborated with São Paulo Polytechnic in Brazil to develop a "cross-border blockchain skill passport," enabling global recognition of certificates. In 2025, the European Union launched the "Green Skills Accelerator," with the Fraunhofer Society in Germany and Delft University of Technology in the Netherlands collaborating to develop a carbon-neutral engineer certification system, covering emerging fields such as hydrogen energy storage and carbon capture technology.

3.Comparative Analysis of Skill-Oriented, Research-Oriented, and Application-Oriented Universities in Literature

Building on the review of the current state of skill-oriented universities, a comparative literature study is essential to fully understand their distinct characteristics. With the continuous deepening of educational reform, China has formally initiated the classification reform of higher education institutions, explicitly categorizing them into research-oriented, application-oriented, and skill-oriented types. This reform aims to optimize the overall structure of higher education, enabling different types of institutions to position themselves precisely and leverage their respective strengths. Simultaneously, it provides guidance for students to choose suitable development paths based on their individual aptitudes.

Research-oriented universities are centers of academic innovation and talent cultivation. As academic beacons within the higher education system, research-oriented universities have academic research and knowledge innovation as their core mission, dedicated to cultivating high-level talents with profound academic literacy and scientific research capabilities (Gu, 2025). Their discipline establishment emphasizes the coordinated development of basic disciplines, emerging disciplines, and interdisciplinary fields. Through a discipline adjustment mechanism driven by both "technological development" and "national strategic needs," they cultivate top-notch innovative talents who serve the nation's pursuit of high-level self-reliance and strength in science and technology. These institutions gather top scholars and high-quality research resources, building first-class research platforms and fostering a rich academic atmosphere. Their discipline offerings are broad and deep, demonstrating significant strength particularly in basic disciplines such as mathematics, physics, chemistry, and biology, as well as in cutting-edge interdisciplinary areas. Research-oriented universities focus on organized scientific research, deepen international exchange and cooperation, and contribute Chinese wisdom to solving common global challenges. Their

graduates predominantly pursue further studies or enter research institutions, universities, and R&D departments of large enterprises, engaging in high-end scientific research and technological innovation.

Application-oriented universities serve as bridges connecting industry and cultivating practical abilities. Application-oriented universities closely align with industrial demands, aiming to cultivate application-oriented talents suited to socio-economic development, thereby acting as a bridge between education and industry. Through the precise alignment of “disciplinary specialty clusters with industrial clusters,” and leveraging platforms like modern industry colleges, they promote the integration of industry, education, and research, focusing on training students’ application competence in solving complex practical problems. Their specialty development revolves around the needs of the local economy and industrial development. For instance, institutions in regions with strong manufacturing sectors prioritize specialties like mechanical engineering and automation, while those in cities with thriving financial services enhance their business programs. Distinct from the “professional competence + adequate theory” model of skill-oriented universities, application-oriented universities emphasize a cultivation system of “broad theoretical foundation + application competence,” focusing on the integrated development of applied research and social service (Luo et al., 2022). Graduates primarily enter the front lines of enterprises and industries, engaging in technology application, product development, production management, and other roles, injecting vitality into industrial development.

Skill-oriented universities are cradles for vocational skill training and master craftsmen. Skill-oriented universities specialize in cultivating applied talents with exquisite professional skills, serving as crucial bases for nurturing master craftsmen. They establish an integrated educational system encompassing “industry, sector, enterprise, specialty, profession,” achieving precise alignment between educational resources and industrial demands through city-based industry-education consortiums and sectoral industry-education integration communities (Gu, 2025). Their specialty offerings are highly targeted, closely aligned with the requirements of specific vocational posts. For example, Culinary Arts and Nutrition programs train talents with advanced culinary skills, while Numerical Control Technology programs cultivate skilled operators of CNC equipment. Differing from the “application competence” focus of application-oriented undergraduate education, skill-oriented universities center on professional competence, constructing a “work-integrated learning” educational model that emphasizes the systematic teaching of technical and skill knowledge (Luo et al., 2022). Teaching is primarily hands-on and practical, equipped with advanced training facilities and specialized training venues that simulate real work environments. In terms of educational levels, skill-oriented universities cover a continuous training path from secondary vocational to higher vocational and vocational undergraduate education, whereas application-oriented universities extend to professional master’s and doctoral levels (Luo et al., 2022). Graduates, armed with strong professional skills, directly enter related industries and enterprises, taking up front-line roles in production, manufacturing, technical services, and similar areas.

4.Current Challenges in the Development of Skill-Oriented Universities

Currently, the development of skill-oriented universities faces three major challenges. Firstly, there is significant difficulty in the dynamic adaptation of educational models to industrial demands. Most skill-oriented universities currently grapple with the challenge of a disconnect between their educational models and industry needs. Although many institutions have explored industry-university cooperation models, their curriculum design and teaching content often lag, resulting in a mismatch between the skills of graduates and job requirements. For instance, Li et al. (2025), through empirical analysis based on statistical data and job market crawler data on the alignment between talent supply from Jiangxi higher vocational colleges and enterprise demand, found a visible structural deviation in the supply and demand of skilled talents. There was a clear insufficiency in the cultivation of skilled talents for traditional producer services, as well as labor-intensive and capital-intensive manufacturing. Similarly, skill-oriented universities in Shenzhen face the issue of an oversupply of skilled talents for some traditional industries alongside an insufficient supply for high-end manufacturing and strategic emerging industries. Zheng et al. (2024) pointed out that the diversified development of higher education needs to align with the multi-level demands, multi-directional cultivation, and sustainable development of skills in a skill-based society. However, current talent cultivation models in China’s higher education exhibit a degree of rigidity, making it difficult to meet rapidly changing industrial needs. On the other hand, the diversity and complexity of industrial demands also increase the difficulty of adapting

educational models. The demand for skilled talents varies across regions and sectors, requiring educational models to balance common needs with personalized training requirements.

Secondly, industry-education integration often manifests as superficial collaboration and needs to evolve towards co-construction and deep innovation. From the perspective of university-enterprise cooperation, the forms of collaboration are relatively singular, primarily focusing on the establishment of internship and training bases, student employment recommendations, etc., with less depth in areas like curriculum development, teaching content updates, and scientific research collaboration. For example, the level of enterprise participation in university curriculum development is low, failing to fully leverage the practical experience and professional expertise of enterprises within the industry, leading to a disconnect between curriculum content and practical industrial applications (Yang et al., 2024). Ke and Wang (2022), taking the first batch of national modern industry colleges in the Guangdong-Hong Kong-Macao Greater Bay Area as a case study, explored the construction path of talent cultivation systems in modern industry colleges, emphasizing the educational philosophy of multi-party collaboration, the establishment of modern management structures, and the cultivation of industrial application and practical abilities. Drawing lessons from this, Shenzhen higher vocational institutions should strengthen cooperation with industries and enterprises, jointly establishing industry colleges, internship and training bases, and technological innovation platforms to propel industry-education integration towards deeper development. Through university-enterprise cooperation, jointly formulating talent cultivation schemes, developing curriculum systems, and implementing teaching processes can achieve a seamless connection between talent cultivation and enterprise needs.

Thirdly, digital-intelligent technologies pose challenges for reconstructing the teaching scenarios of skill-oriented universities. The rapid development of digital-intelligent technologies presents both opportunities and challenges for reconstructing teaching scenarios in skill-oriented universities. The opportunity lies in the ability of these technologies to provide richer teaching resources and methods. Technologies like Virtual Reality (VR), Augmented Reality (AR), and Artificial Intelligence (AI) can create immersive learning environments, enhance student interest and engagement, and promote personalized and self-directed learning. However, the challenges cannot be ignored. On one hand, the application of digital-intelligent technologies requires universities to possess corresponding hardware facilities and software platforms. Some institutions face deficiencies in digital-intelligent infrastructure, hindering the effective application of these technologies. On the other hand, the rapid iteration of digital-intelligent technologies places higher demands on teachers and students, requiring them to continuously learn and adapt to new technologies and tools. Otherwise, disparities and imbalances in technology application may arise (Hu et al., 2025; Zhang et al., 2025). In teaching scenarios empowered by digital technologies, lessons can be drawn from the experience of integrating generative AI into digital media curriculum development. Based on technology diffusion theory, a four-stage cultivation model of “technology understanding, tool mastery, creative transfer, ethical consideration” can be developed to systematically reshape the curriculum system.

Therefore, building high-level skill-oriented universities in Shenzhen urgently requires transformation, upgrading, and connotative development:

- (1) Establish a dynamic program and curriculum adjustment mechanism: The program adjustment cycle in current skill-oriented universities is generally lengthy, creating a significant disconnect with the rapid technological iteration pace of “20+8” industrial clusters.
- (2) Improve the industry-university collaborative education system: University-enterprise cooperation often remains at superficial stages like “order-oriented classes” and “training bases,” with insufficient depth in enterprise participation. The industry college model partially addresses this issue but still exhibits tendencies towards superficiality and lack of depth.
- (3) Construct a digital-intelligent empowerment development path: Integrate digital-intelligent, cross-disciplinary, and personalized learning resources. Through intelligent, modular, and collaborative learning platforms, provide high-level skill learners with flexible, diverse learning pathways and rich learning experiences.

5. Conclusion

By reviewing the development history, typological analysis, and current challenges of skill-oriented universities, we can provide theoretical support and practical insights for building highlands of skilled talent cultivation. In the process of

empowering skill-oriented university development with high-quality digital-intelligent technologies, urgent focus is required in the following three areas. First, upgrade the program and curriculum mechanism of skill-oriented universities to establish a dynamic adaptation mechanism aligned with industry. Second, transform the industry college model of skill-oriented universities by deepening the industry-university collaborative education system. Finally, explore the digital-intelligent development path for skill-oriented universities to construct a new model where digital-intelligence empowers industry-education-research-application.

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Research on the Development of Coordination Ability and Training Methods of Junior Volleyball Players

Qian Wang¹, Yuchen Guo^{2*}

1. Belarusian State University of Physical Education, Minsk 220020, Belarus

2. Department of Global Convergence, Kangwon National University, Chuncheon-si 24341, South Korea

*Corresponding author: Yuchen Guo, guoyuchen2024@163.com

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Abstract: This paper focuses on the development of coordination ability of junior volleyball players, and discusses the key role of coordination ability in volleyball training by combining technical means and feedback mechanisms. This paper systematically analyzes the age characteristics, classification methods and relationship between coordination and the sensitive period, and points out that this age group is a critical period for the formation of strong nervous system plasticity and motor skills. On this basis, diversified teaching methods including general preparation exercises, special coordination tasks, and circular training are proposed, emphasizing the systematic, adaptable and individualized training content. The study believes that the scientific and rational use of the sensitive period, combined with modern training methods, can significantly improve the coordination, reaction speed and sports adaptability of young athletes, and lay a solid foundation for their long-term development.

Keywords: Coordination Ability; Volleyball Players; Sensitive Period; Training Method

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1. The main manifestations of the athletic ability of volleyball players

1.1 The relationship between age and coordination ability

The modern volleyball system aims to create a training method that contributes to the education of high-level athletes. The main focus is on developing innovative strategies to organize and systematize player development, thereby ensuring stable and long-term improvement in player performance. The strategy is based on a rethinking of traditional methods, emphasizing personalized coaching and employing modern methods to evaluate and correct movements.

One aspect of the training is age staging, which covers developmental stages from 4 to 17 years old. During this period, coordination skills underwent significant changes, which became the basis for the successful development of volleyball technology. The problem of diagnosing these abilities is closely related to the study of their formation of natural laws, and there are different views on this problem in the scientific community^[15].

For example, M.M. Bezrukich noted that in children aged 6 to 9 years, visual control plays a leading role in controlling movements. It was during this period that children underwent an important transformation: children began to not only succumb to intuition and observational control, but also relied on preset motor programs that significantly reduced the time of movement cycles by increasing speed and accuracy. During the 6-8 year gap, there is a significant age-related jump in coordination function, when motor areas of the cerebral cortex are actively formed. At the same time, the functional values of

the frontal lobe and the junction region change, affecting the body's ability to control activation and coordination processes^[4]. Research by V.K. Balsevich and colleagues showed that training in children of about 4 years helps the basic components of coordination, especially those related to reaction speed, develop most quickly. As children grow up at the age of 5, the characteristics of time and strength develop better, and by the age of 6, the socio-temporal skills improve significantly. These data indicate the existence of the so-called sensitive period, i.e. the body is particularly susceptible to certain motor activities^[3]. Analysis of age characteristics showed that the peak sensitivity of coordination development occurred in primary school age and the first half of adolescence. Thus, the intensity of the development of certain functions increases almost fivefold in girls aged 8-9 years, and in the period from 9 to 10 years this figure is about 3.2 times that of 13-14 years old. Dynamic balance is especially active between the ages of 7 and 10, which is an important factor in the training of volleyball players. In addition, from 4 to 16 years old, the ability to accurately distribute forces in space has increased by more than five times. The results of the standing long jump test showed that the best accuracy of the movement occurred at two key age stages - early childhood (4-6 years old) and high school threshold (9-10 years old). Interestingly, the number of sensitive periods during adolescence (11 to 14 years old) decreases significantly – at least by half. However, by the age of 14-15, the indicators of girls return almost to the level typical for 9-11 years. Boys, especially in secondary school, have significant biodevelopmental potential despite a temporary decline in symptoms at the age of 12 to 13, which correlates with the active formation of speed and strength^[14].

The time frame for the formation of coordination in children's individual development cannot be considered to be a universal biological law. When the same characteristics are assessed using the same methodology, different researchers draw ambiguous conclusions about sensitive developmental periods. Such diverse explanations stem from individual differences in children's biological growth and development rates. For example, girls with average physical development indicators reach the peak of coordination at about 12 years of age. At the same time, the improvement in coordination is similar in all girls compared to the level of eight-year-olds, regardless of their biological developmental peculiarities.

Boys with average physical development have two pronounced periods of agile growth – one at 8-9 years old and the other at 11-12 years old. These observations suggest that favorable biological conditions for the formation of coordination are manifested in early childhood and adolescence, while these stabilization processes occur in high school.

L.V. Volkov described in detail in his work the dynamics of the development of coordinated nature. He noted that during the formation process, there are three periods of significant growth in these abilities: 8-9 years, 11-12 years, and finally 14-15 years. Volkov also distinguishes three main categories of coordination and associates them with specific age-sensitive periods. Thus, spatial orientation begins to develop as early as 5-6 years of age, sensitivity peaks between 7 and 10 years of age, stabilizes at 10-12 years of age, decreases slightly during adolescence (14-15 years), and compares with adult indicators at 16-17 years of age. Particular attention is paid to the ability to distinguish the rhythm of movements, which begins to form around the age of 7-8 years. At the same time, children aged 5 to 10 years are at the lowest stage of development in terms of muscle effort distribution capacity, suggesting that further correction and formation are needed in subsequent growth stages^[7].

Figure 1: Age and coordination development table

Age group	Main development characteristics	Influencing factors
4-6 years old	Visual control, basic coordination	Nervous system development, sports experience
6-8 years old	Presets of exercise programs to speed up the action cycle	Behavioral observation, reaction speed
8-9 years old	Dynamic balance and spatial positioning capabilities are significantly enhanced	Physiological changes, sensitive periods
11-12 years old	Stable coordination, jump strength and speed	Hormonal changes, psychological maturity
14-15 years old	Highlight coordination and gradually mature skills	Biological development and training accumulation

1.2 Classification of coordination ability

The joint research of L.V. Volkov and colleagues allowed us to consider coordination as a multifaceted manifestation of

motor activity. First of all, they include high precision and coherence of movements, reaction speed, flexibility, as well as a developed sense of rhythm and rhythm. It is also important to be able to tense and relax muscles in a timely and correct manner, which allows the body to adapt to the changing environment and adjust the movements to the situation.

Other authors have proposed another classification of coordination ability. They fall into three main categories: The first covers the ability to accurately measure and regulate spatial, temporal, and dynamic parameters of motion. Skills such as “sense of space”, “sense of balance”, “sense of timing” and “sense of muscle” fall into this category ; The second category embodies the ability to maintain balance – whether in a stationary position (maintaining a stable posture) or in dynamic conditions such as skating, skiing, or handstands ; The third category includes skills that allow you to perform motor movements without excessive tension and stiffness, which is essential for the effective and smooth execution of movements^[15].

V.A. Romanenko proposed to examine coordination from multiple perspectives, dividing it into the following categories: the ability to form motor programs, the ability to maintain balance, and motion control considering spatial dynamics and spatiotemporal characteristics^[17]. This method allows you to fully assess the body’s ability to not only perform certain actions, but also adapt to changing environmental conditions.

Subsequently, V.M. Naskalov proposed his own classification, distinguishing the following categories of coordination abilities:

Spatial and visual orientation is determined by the amount and accuracy of perception and the processing of spatial information received from the environment.

Reactivity – characterized by the speed of nerve impulse conduction and the speed at which the optimal solution is found under the selection conditions.

Rhythmic ability is manifested by the coherence of continuous dynamic changes in excitation and inhibition in the nervous system, as well as the harmonious interaction of various nerve centers.

Balance skills – involves using vestibular information effectively to program and correct movements.

Intermuscular coordination reflects the rational and economic interaction of various muscle groups in the process of performing specific actions.

Exercise program restructuring – demonstrating rapid adaptation, stopping the implementation of established plans, and switching to new protocols in response to environmental changes^[16].

In the context of volleyball, many coordination skills are given special importance. Among them, the ability to respond quickly, differentiate motion parameters, orient spatial and establish connections between various moving elements is particularly prominent^[9]. These qualities help athletes adapt to rapid changes in the pace of the game, respond quickly to opponents’ movements, and maintain a high level of performance accuracy.

Research by A. Schnabel and V. Starosta^[21]. Focus on the methodological importance of technology and coordinated interaction. The authors recommend putting coordinated training in the first place, developing tasks, selecting methods and methods based on the athlete’s multi-year stage of progress. This approach allows you to take into account the characteristics of individual development, thereby enhancing the effectiveness of the training process.

Several studies conducted by V. Rathod and V. Rai^[19], demonstrating the importance of considering age characteristics in the formation of various motor coordination. This approach mirrors Bernstein’s principles, emphasizing the need to synchronize educational influences with the biological characteristics of human development. At different stages of ontogeny, the results of training may vary: at some stages, emphasis on the development of motor skills gives the best results, while at others, the effect is less pronounced. Only a detailed analysis of age characteristics and adjustment of training loads will maximize the potential of each athlete.

1.3 The relationship between the sensitive period and the training effect

It is important to use the concept of “sensitive period” when planning the training process, based on age-related data on athletic performance development. Research in this area distinguishes between stages characterized by active growth, subsequent stabilization, and slowed developmental rates. Interestingly, the sensitive period covers not only motor abilities, but also intellectual, musical, and mathematical abilities. In this context, V. Lyakh and collaborators proposed a scale that

assesses the development of motor competence, conditionally dividing it into three levels. According to their findings, if the mass growth rate exceeds 3%, it indicates the entry into a sensitive period, and it is recommended to devote up to 30% of training time to the development of this trait. For the nature of the average growth rate (about 2%), the best option is to spend 20% of the time and at a lower rate – only 10% ^[18].

The researchers' observations show that the development pattern of coordination is heterochronic, that is, the development is uneven across different age groups. Of particular importance is the comparative analysis of children and young athletes who are not involved in sports ^[19]. This comparative approach not only assesses the impact of targeted training on coordinated development, but also provides valuable data to establish effective long-term training programs for children and adolescent sports schools.

J.Szymonek and his co-authors emphasize the importance of careful planning and personalized selection of training loads, taking into account the potential capabilities of each young volleyball player. They argue that the success of purposefully developing movement traits directly depends on the period in which these traits show the greatest growth. The researchers point out that when training focused on the development of coordination competencies coincides with periods of intense growth associated with age, there is a so-called "maximum rate of progress". Conversely, at the stage where the growth rate is below maximum or moderate, the improvement in coordination skills is less obvious ^[20].

V. Liach and Z. Witkovsky ^[18] argues that the concept of a sensitive period is controversial among experts. There are various opinions on whether the training effect is always obtained during periods of accelerated development of certain motor skills. However, the methodological principles that require taking into account the individual characteristics and developmental details of each athlete are still generally recognized. An important aspect is to focus efforts on improving the functioning of the so-called "proximal developmental zone", rather than trying to influence the already fully formed motor skills.

As noted by V.Y. Mayakina, although sensitive periods are important, simply considering these periods is not enough to effectively help young athletes ^[15]. The authors make a strong argument that continuous diversification of training methods throughout developmental stages is a key condition for the formation of stable motor memory. This strategy allows the body to quickly rebuild the exercise routine and learn new motor skills. Considering the complexity and variability of loads, the planning and standardization of coordinated training is still a hot issue that urgently needs scientific basis and practical improvement.

If we talk about coordination, it can be described as the body's ability to accurately and continuously execute motor instructions from the cerebral cortex ^[2]. Scientists have found that certain age groups are more sensitive to various external and internal influences ^[3]. It is during these moments that the development of specific functions is most remarkable, providing a wide range of opportunities for purposeful work by experienced teachers and coaches. Therefore, if these windows of opportunity are used correctly, volleyball coaches have every chance of significantly improving the coordination skills of children in primary school age.

Figure 2: Relationship between sensitive period and training effect

Sensitive period	Recommended training time ratio	Training type
4-6 years old	30%	Motor skills and sensitivity training
7-9 years old	30%	Coordination ability, reaction speed training
10-12 years old	20%	Technical improvement, tactical awareness
14-15 years old	10%	Fine skills and psychological quality improvement

Teaching experts concluded that the optimal age range for establishing a foundation for coordination is 7 to 12 years ^[2]. During this period, not only physically, but also psychologically, children have the highest acceptance of learning, which lays a solid foundation for further motor growth. As the training burden increases, children gradually accumulate physical condition while activating various resources of the brain and the whole body ^[6]. This cumulative effect helps uncover potential and adapt to new environments.

In the context of volleyball, those physical qualities that contribute to the development of coordination are of particular

value. These include the suddenness of the impulsiveness of action, race endurance, the ability to jump and control falls, and a variety of gaming techniques. All this suggests that the basis of high coordination lies in the adaptability of the nervous system and the body as a whole. It is especially important to note that at the age of 7-9 years, fetal plasticity is formed, which allows the baby to effectively adapt to external influences, opening up opportunities for further improvement.

In conclusion, it can be said that modern methods of studying sports coordination encompass a wide range of features - from the basic skills that form motor programs to the complex adaptation mechanisms that enable athletes to successfully cope with environmental changes. A comprehensive understanding of these processes based on interdisciplinary research and age profiling analysis is key to building an effective training system and promoting the optimal development of young athletes' physical fitness. The formulation of individual training programs should take into account age characteristics and developmental stages, as well as the specific requirements of volleyball coordination ability. The integration of the concept of sensitive periods, the principle of load individualization, and a variety of methodological techniques have laid a solid foundation for young athletes to successfully develop sports skills. This interdisciplinary approach not only maximizes each child's biological potential but also sets the stage for his future athletic achievements.

2. Teaching methods and methods for developing the coordination skills of junior volleyball players in the education and training phase

2.1 The importance of cultivating coordination

Coordination development in young volleyball players is carried out through long, age-appropriate training, in which all aspects of sports activities are improved. Key elements of the process include: Improving the body's motor function. The gradual development of motor skills contributes to more accurate performance of movements, which directly affects the success rate of physical activity; Accuracy in the execution of actions is obtained. Regular training helps develop the ability to complete exercises with high accuracy and coordination; General health promotion. Physical activity aimed at developing coordination has a positive effect on the immune system and the overall condition of the body; The formation of self-discipline. The training process fosters a sense of responsibility, perseverance, and self-organization in athletes, which is important not only in sports but also in everyday life ^[5].

Through professional planning and training methods, volleyball has high potential. During training, gradual microevolution of physical fitness was observed: improvements in muscles, ligaments, and vestibular apparatus contributed to the overall coordination and adaptability of children ^[4]. The main goal of coordination skills development is to optimize the sports training of volleyball players and prepare them for future sports achievements. This means the ability to apply the learned skills in conditions of increased loads, both in training and in competitions.

A.N. Anaprienko noted the general tasks that coaches and teachers face in coordination work:

The system develops new motion elements. It is important to constantly introduce universal and special preparatory coordination exercises to promote diversity in movement patterns.

Improvement and adaptation of movements. Practicing skills in various conditions is necessary, which allows volleyball players to confidently respond to changes in the game.

Comprehensive training, including the performance of complex technical elements and active tactical interaction, demands a high level of physical fitness. In the tense pace of the game, especially under force pressure, athletes must make quick decisions, adjust tactics, and maintain high intensity until the final seconds of possession. ^[1]

An equally important aspect of an athlete's development is an innate physical trait due to genetic predisposition. These basic features are formed based on the activation of morphofunctional processes, ensuring maximum performance of physical activity when performing purposeful motor tasks. I.V. Avramov's physical qualities include flexibility, endurance, strength, speed, and of course, coordination, which are the main physical qualities ^[2].

Coordination depends not only on physical factors, but also on neuromodulation of movements. For volleyball players, such an element as stability balance is very important - the ability to maintain a stable posture under dynamic and static loads; Site orientation – the ability to correctly perceive and analyze spatial information, which is essential for timely decision-making; Differentiation of exercise parameters – the ability to quickly adapt and reconstruct the exercise program according to the

competition situation. These factors manifest themselves in a variety of speeds: from the speed of analysis of the situation to the rapid adoption of management decisions, which in turn affect the speed of action and the effectiveness of the execution of technical techniques. According to N.V. Egrashkin, the speed and agility of a volleyball player are determined by all these factors together, since they are an important part of almost all movements in the game^[10].

A.P. Kolomiets emphasizes that the development of coordination is directly related to the symmetry of movements. Particular attention is paid to the even distribution of left and right hand strength, which is especially important when performing up and down catches and passes^[12]. Over time and as motor skills improve, muscle sensation can develop subtle differences, improving the accuracy and economy of movements.

S.P. Galbtsov noted that the performance of coordination depends on a number of factors, including the ability to accurately analyze movements, the work of the analyst (especially a sports analyst), the complexity of the task performed, the more complex the task, the higher the coordination requirements, the level of development of other physical qualities, speed characteristics, dynamic strength, flexibility and other factors affect the overall effect of the action, the nature of personal qualities, such as courage and determination. The age of the athlete plays an important role in the acceptance of learning and adaptation to the load. Overall preparation is equally important, including having a diverse and varied athletic skill, which is key to a successful sports career^[7].

The development of coordination in volleyball players is a process in which their control of their movements improves and they develop the ability to adapt quickly to changing conditions of the game. This includes not only the precise execution of movements, but also the ability to reconstruct motor activity in real time and confidently control one's body in an unsupported position. Any exercise that meets at least one of these criteria can be classified as coordination.

2.2 Systematic principles and practice classification of coordination training

Systematic coordination means using a common set of preparatory exercises that are diverse and adaptable. There are many factors to consider when choosing and planning such events. First of all, these periods are the time allotted for coordinating work in order to avoid disrupting the balance of extracurricular activities, extracurricular activities or other physical activities within the framework of independent training. In addition, the age, gender and individual characteristics of the student should be considered. For example, at school age, boys are often offered exercises such as kettlebells, dumbbells, or barbells, while girls are characterized by using hula hoops, sticks, ribbons, ropes, and balls. We should not neglect material and technical support: the availability of equipment and inventory also plays an important role in the organization of the course^[6].

Researchers generally divide general preparatory coordination exercises into four broad categories. The first category includes exercises aimed at developing basic life skills. Here we are talking about the introduction of new movements or variants of known exercises recommended for students in grades 1 to 5 in the school curriculum. The second category covers exercises that promote the expansion of the exercise experience by performing a variety of general preparatory tasks. These exercises can be performed with a variety of objects – sticks, jump ropes, balls or sticks – as well as in solo or double performances, while the performance conditions can change: change body position, direction of movement and other parameters.

The third group includes general developmental exercises, which include physical and acrobatic elements, as well as running and jumping exercises. The focus here is on the development of endurance, strength and speed. The fourth group of exercises focuses on the psychophysiological functions of the body. These tasks help to form a sense of space and time, while helping to accurately regulate muscle effort and develop motor memory and intentional responses—that is, muscle impulses generated when a person mentally imagines an action^[6].

The variety of methods for developing coordination skills is also worth paying attention to. Among them, there are some strictly controlled exercise methods, which can be classified according to several characteristics. On the one hand, a distinction can be made according to the degree of selectivity of the influence: exercises that intentionally affect homogeneous coordination skills can be distinguished from broader exercises that affect a set of motor skills. On the other hand, depending on the nature of the task, the exercises are divided into standard repetition and variable, the latter implying variability in performance conditions that help coordinate the more flexible development of skills.

V.G. Bubenshikova emphasized that the effective development of coordination skills requires the use of physical exercises

that meet a number of specific requirements. First, this type of exercise should be associated with overcoming coordination difficulties, which stimulates the body's adaptive response. Secondly, a volleyball player needs to perform complex motor movements with high accuracy and speed, which allows him to rationally use his physical abilities. Third, the innovation and originality of the task are very important, which can change the regular course of the action or the conditions for its execution, and create new developmental stimuli ^[6].

According to S.P. Garbuzov, the key tool for developing coordination in volleyball players is physical exercises, which have a high degree of coordination complexity and contain novel elements ^[8]. It is these exercises that stimulate the neuromuscular system, aiding in the quick and accurate implementation of complex exercise regimens, which is especially important in a dynamic competition environment.

With a variety of methodological approaches, the complexity of the exercises can be significantly increased. Among them, the following methods can be distinguished. Modification of spatial, temporal and dynamic parameters. By changing the trajectory of movements, the speed of execution, and the cadence of movements, coaches create additional stimuli for the adaptation of the athlete's coordinated responses. Adjustment of external conditions. Using non-standard arrangements of shells, changing their weight and height, it is possible to introduce unexpected elements, which require volleyball players to quickly reorganize the locomotor system. Change the support area. Using unstable surfaces or movable platforms in balance training forces athletes to actively activate stabilizing muscles and improve body control. A combination of multiple motor skills. The combination of walking, jumping, and running with the use of balls or other objects creates a diverse range of movements that promote complex adaptations of motor skills. Introduce elements that respond to signals. Completing a series of exercises on command or in a limited amount of time not only develops coordination, but also improves reaction speed, which is extremely important for tactical games. This approach makes it possible to incorporate coordination exercises into the training process, especially when volleyball has specific technical and tactical requirements ^[8].

When performing volleyball training, it is recommended to use two main types of coordinated training methods. The first category includes leadership exercises aimed at actively developing new forms of action. These exercises help athletes become familiar with multiple movement modes, which is important early in training. The second group includes developmental exercises specifically for basic coordination skills in volleyball. For example, completing special tasks in difficult conditions, such as catching the ball while jumping on the bench and passing it to a partner, or rolling continuously on the mat and passing the ball over the net after receiving the ball, can help develop adaptability in close to playing conditions.

Figure 3: Coordination training exercise classification table

Practice categories	description	target
Basic life skills exercises	Introducing new movements and variations of known exercises	Helps athletes master basic sports skills
Universal preparation tasks	Perform multiple tasks, apply different objects and vary performance conditions	Expand the sports experience
General developmental exercises	Contains elements of endurance, strength, and speed	Improve physical fitness
Psychophysiological function exercises	Develop a sense of space, time, motor memory and intentional response	Enhance muscle regulation and responsiveness

3.The main teaching methods for developing coordination ability

3.1 Basic coordination exercises

An essential component of comprehensive training for volleyball players is a skillful warm-up, which is essential for the development of coordination. Before performing the main movements, the trainer must make sure to include a specially selected set of physical tasks that will help prepare the body for the upcoming load. This warm-up helps activate plant functions, improve overall performance, and optimize the state of the muscular system, thereby maximizing the performance efficiency of complex exercise regimens. ^[8].

During running or walking training, special attention is paid to coordination with the ball, which not only helps to master passing skills, but also develops coordination of movements in dynamic sports conditions.

Pass the ball forward. During the running movement, the athlete must confidently pass the ball strictly forward, ensuring that the arm remains straight and the movements are coordinated throughout the movement.

Flick the ball forward with your clapping hands. The exercise consists of simultaneously clapping forward to throw the ball to high ground, while the ability to catch the ball accurately and without delay is also important.

Throw the ball behind your back. Here, the athlete needs to throw the ball over his back and successfully catch it, which contributes to the development of spatial perception and motor flexibility.

Pass the ball over the net. This exercise is designed to practice the skill of hitting the ball out of the goal instead of touching the net, which requires precision and synchronization of movements. In this exercise, the ball is thrown up and then slapped on the back or chest to catch the ball without falling.

Possession of the ball behind the scenes. This movement involves dribbling the ball from behind, forward and up, and throwing it over the head, then catching it and passing it to a partner, which helps develop the ability to coordinate movements in non-standard positions.

A dynamic combination of throwing and squat. At this point, the ball is thrown to the high ground, and then the athlete touches the ground with both hands to perform a squat, catch the ball, and keep it in the hand, which helps improve reaction and synchronization of movements.

3.2 Comprehensive and coordinated training

To foster teamwork and coordination, it is important to practice in pairs, including the following options:

Passing the ball between players. It is a classic exercise in which one athlete passes the ball to another athlete by testing the accuracy and speed of the pass.

Change the bounce height. Here the ball bounces at different heights and then passes to the partner, which requires adapting to changing circumstances.

Possession of the ball in your territory. Exercises based on the connecting ladder technique help improve ball control in tight spaces.

Pass the ball with a squat movement. When passing, the athlete must do squats, which increases the element of physical activity and improves coordination when changing body positions.

Passed to the wall. In this exercise, the ball is passed at a specific location on the wall, helping to develop a sense of spatial direction and throwing accuracy.

Elements of dance steps. Balls with elements of dance movements on the field contribute to the development of shaping abilities and multiple motor skills.

In addition, pair exercises should provide for the option of passing the ball by bending the body in different directions (forward, sideways, backward), as well as movements such as squats and jumps. This helps foster the flexibility and reflexes needed for dynamic gaming.

After warming up and before the main training, a series of stretching movements should be performed. The main goal of the project is to increase the range of motion of various parts of the body, help improve the overall physical condition of the athlete, improve joint flexibility and muscle elasticity, and create conditions for the full development of muscle potential during competitions. With a sufficient range of motion, volleyball players can perform technical movements more accurately and perform more efficiently, which directly affects physical health and performance.

To develop coordination skills comprehensively, it is recommended to include a variety of exercises that help form motor memory and improve motor skills during training. Such exercises include:

Forward somersault over the top of your head. The athlete completes a jump with the elbow bent, followed by a forward flip above the head. It is also important to be able to do up to 10 repetitions evenly spaced.

The somersault goes back from the top of the head. The move consists of a reverse somersault followed by arm flexion as you land, helping to quickly regain ability after a fall.

Do somersaults on both sides. The rotation of the roll back and forth promotes symmetry and coordination of movements.

Exercises for falling and getting up quickly. These tasks are designed to develop reflexes and the ability to recover quickly from falls, which is especially important in competition.

Body action (wheel). The left and right rotating wheels help improve overall coordination and build muscle endurance.

To enrich the training process and improve the coordination of young volleyball players comprehensively, circuit training techniques are recommended. The technique consists of performing several exercises in a row, each aimed at developing a specific physical fitness:

Change the direction of movement. Exercises involving steering include dribbling exercises, stake exercises, or raised jumps, which train the ability to adapt quickly to changing environments.

Exercise the development of the strength component. Alternating throws of different weights for high jumps or long jumps with different power loads can help improve the power and accuracy of the movement.

Comprehensive exercise. In this module, tasks require alternating throws and jumps, which helps improve strength and coordination.

Walk in squat motion. Athletes use body benches to walk in full squat positions, which helps with endurance development and balance.

Walk with an extra burden on your back. To increase weight-bearing, exercises with a sandbag above the athlete's head can be added while walking, which requires concentration and improved coordination.

Group play activities. With the addition of games such as "cockfighting", teammates jump on one leg and perform ball game elements, which not only promotes the development of coordination skills but also promotes team interaction.

This set of exercises covers a wide range of techniques designed to develop coordination skills in volleyball players. From training with the ball in running or walking conditions, to stretching, general body exercises and circuit training elements – all of these not only improve technical skills, but also form stable motor memory, improve reaction speed and adaptability. This multi-stage and integrated approach to training contributes to high individual and team results, creating a strong foundation for volleyball player success.

Conclusion

The formation of coordination in junior volleyball players depends on unique physiological conditions and sensitive periods of the most active development of motor skills. The plasticity of the nervous system during this period allows you to effectively master basic and complex motor programs, laying a solid foundation for further motor growth. Personalized training methods and diverse methodological techniques help optimize the development of coordination, adaptability and reaction speed, which are also key conditions for successful training for young volleyball players. The development of coordination skills in junior volleyball players requires an integrated and systematic approach based on age-adaptation methods and exercises. The use of a variety of teaching methods – from general preparation and specialized tasks to exercises with variable parameters and circuit training elements – not only helps improve the accuracy, speed and stability of movements, but also promotes the formation of motor memory, self-discipline and adaptability. This multi-stage collaboration provides a solid foundation for the development of sports and the successful realization of the potential of young volleyball players at both the individual and team levels.

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The Association Between New Media Environmental Stimuli and Chinese Athletes' Mental Health: An Environmental Psychology Perspective

Hening Wang, Chun Zhang, Ruifeng Liu*

Faculty of Health and Wellness, City University of Macau, Macao, 999078, China

*Corresponding author: Ruifeng Liu, lrff@qq.com

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Abstract: With the development of new media technology, the social environment in which athletes reside has undergone a fundamental transformation. Based on the perspective of environmental psychology, this study analyzes how the environmental characteristics of new media influence athletes' mental health. The study finds that the new media environment forms systemic pressure on athletes across three dimensions: physical, social, and temporal. Specifically, the high-intensity information stimuli in the physical dimension increase cognitive load and induce anxiety; the public evaluation and polarized public opinion in the social dimension lead to a surge in social pressure and a decline in self-efficacy; and the continuity in the temporal dimension causes a substantial depletion of psychological resources. In the Chinese cultural context, collectivist values, shame culture (Face), and expectations of moral perfection further amplify the negative impacts caused by the new media environment. Therefore, this study emphasizes that protecting athletes' mental health cannot rely solely on individual-level interventions but requires regulation and management at the environmental level. This research provides a theoretical basis for understanding athletes' mental health issues in the new media era and offers practical references for optimizing the ecological environment of competitive sports.

Keywords: New Media Environment; Athlete Mental Health; Environmental Psychology; Cultural Moderation; Environmental Stimuli

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1.Introduction

In the development process of Chinese competitive sports in the new era, building a leading sports nation is a crucial goal in the comprehensive construction of a modern socialist country. Under this strategic guidance, the sports demeanor (or sports image) has been placed in a more central position than competitive results alone. In competition scenarios, athletes' speech and deportment, performance under pressure, and the manifestation of sportsmanship have become important dimensions for measuring the development of Chinese sports. Athletes' mental state is the core prerequisite for shaping a positive sports demeanor; this state is not only a key determinant of competitive performance but also directly affects the tangible expression of sportsmanship. However, the media environment in which athletes are situated has undergone a fundamental transformation in the past decade, bringing unprecedented challenges to athletes' mental health.

For a long time, sport psychology research has mainly focused on the relationship between anxiety and performance in

competitive settings. However, this traditional perspective primarily focuses on internal stressors, often overlooking the critical impact of broader organizational environments and social factors on athletes. The rise of new media technologies, represented by social media, has fundamentally changed the ecological environment in which athletes exist. The new media environment refers to a digitized and networked communication ecological environment composed of social media platforms, instant messaging tools, and short video platforms. Unlike the one-way communication, professional gatekeeping, and delayed reporting of traditional media, Jenkins points out that the new media environment has formed a participatory culture, characterized by the ability of anyone to produce and disseminate content, the diffusion of information across social networks, and the immediate occurrence of feedback and commentary. These three characteristics together constitute a brand-new communication environment. Its impact on individual psychology no longer stops at the level of passive information reception but forms a field of continuous operation and multi-party interaction, resulting in the dissolution of athletes' individual boundaries. In the new media environment, athletes' training, competitions, and private lives exist in a state where the boundary between public and private disappears. Any behavior or emotion can be recorded, disseminated, and trigger comments, forming continuous public opinion pressure.

More critically, the new media environment is not a communication tool that athletes can choose to opt out of, but an objectively existing networked public space. Even if athletes do not use social media, discussions about them still occur, and pressure is still transmitted. To deeply analyze how this permeable and uncontrollable external networked public space is internalized into athletes' psychological pressure, it is necessary to depart from traditional communication dimensions and introduce the analysis of environmental psychology. The environment is by no means a passive physical background but an active factor that intervenes in individual psychological processes. This implies that the new media environment, as a field with specific stimulus characteristics, generates immediate impact and profound cumulative effects on individual cognition, emotion, and behavior. However, existing research on the impact of new media on athletes mostly starts from social media usage behaviors or individual coping strategies, rarely viewing new media as an independent environment to analyze its stimulus characteristics.

It should be particularly noted that cultural background is a key factor influencing environmental stimuli and individual psychological responses. Collectivist values in Chinese culture, the concept of Face (Mianzi), and high moral expectations for role models make Chinese athletes exceptionally sensitive to public evaluation. When the stimulus characteristics of the new media environment overlap with the core traits of Chinese culture, the psychological challenges faced by athletes may be even more severe.

Based on this, this study proposes a core viewpoint: new media, as a transition at the environmental level, has had a significant impact on athletes' mental health, and this issue requires systematic prioritization. This study views new media as an environmental system with unique stimulus characteristics and elucidates how these characteristics directly affect athletes' mental states within the Chinese cultural context. The ultimate goal of this research is to provide a theoretical basis for protecting athletes' mental health and to emphasize the necessity of environmental-level intervention, which is a crucial component in promoting the civilized development of competitive sports.

2.Three-Dimensional Characteristics of the New Media Environment

The new media environment is not merely a channel for information dissemination but a complex environmental system with unique stimulus characteristics. Based on Gifford's (2014) theoretical perspective on environment-behavior interaction, and integrating Rainie and Wellman's social-temporal view of networked individualism and new media technical characteristics, this study constructs an analytical framework comprising three operable dimensions: physical, social, and temporal. This framework aims to reveal the core mechanisms of environmental influence on individual psychology and further explore the unique role played by the Chinese cultural context in this process (Rainie & Wellman, 2012).

2.1 Physical Dimension: High Intensity and Immediate Presence

The physical characteristics of the new media environment are primarily manifested in the high intensity of information stimuli and immediate presence.

High intensity refers to high information density, rapid update speed, and wide dissemination range (Hilbert & López, 2011).

Athletes may face massive amounts of comments and reposts instantly after a competition, with the volume of information far exceeding that of the traditional media era. In particular, influenced by the negativity bias effect, negative information often captures individual attention first, and its processing priority is significantly higher than that of positive information (Baumeister et al., 2001). This means that even if the quantity of positive and negative evaluations is comparable, massive negative information will significantly increase the athletes' cognitive load, forcing them to consume a large amount of psychological resources to filter and defend against information; long-term excessive information overload will lead to decision fatigue and impaired cognitive function (Eppler & Mengis, 2004).

Immediate presence refers to the fact that new media technology has dissolved the barriers of physical space and shortened the psychological distance between communicators and audiences, allowing the real sense of presence of others to be transmitted immediately (Short et al., 1976; Wiener & Mehrabian, 1968). In this field, any performance, error, or even behavior can be instantly recorded, disseminated, and commented upon. In the traditional media era, athletes' performances needed to go through processes such as media editing, review, and broadcasting, providing a time buffer. However, in the new media era, the audience's mobile phones serve as cameras and dissemination tools, and any moment can become the focus of public opinion. This immediate presence deprives athletes of the space for adjustment and buffering. A single mistake may spread across the entire network within minutes, and athletes may face overwhelming comments while still in the competition. The psychological pressure brought by immediate presence lies in the fact that athletes cannot predict or control the spread of information, and this uncertainty and sense of loss of control will significantly increase anxiety levels (Grupe & Nitschke, 2013).

In the Chinese cultural context, the impact of these physical characteristics is further amplified. China has a massive base of internet users and a high rate of social media usage, which means the volume of information and attention Chinese athletes face may be even more substantial. Collectivist culture causes the public to have strong emotional investment in athletes who represent the national image, making both praise during success and criticism during failure more intense (Hwang, 1987). Furthermore, mechanisms such as "Hot Search" (trending topics) and the mobilization capacity of "Fan Circles" (Fandom) in Chinese internet culture make the aggregation of public opinion faster and more intense. This easily triggers cybercascades, subjecting athletes to more violent information shocks that exceed individual psychological defense thresholds, thereby damaging their mental health (Sunstein, 2017; Lu et al., 2022).

2.2 Social Dimension: Evaluative Nature and Group Polarization

The social characteristics of the new media environment are primarily manifested as social evaluativeness and Group Polarization.

First, social media transforms originally ambiguous social evaluations into visible quantified metrics through mechanisms such as likes, reposts, and comments (Van Dijck, 2013). This mechanism leads to Context Collapse, where distinct audience groups (such as coaches, fans, media, and critics) that were originally segregated by physical settings in real life are compressed into a single interactive context by new media technology (Marwick & Boyd, 2011). For athletes, this means they must simultaneously cope with multiple expectations within a flattened space; they no longer face specific individuals but rather an "Imagined Audience" that is difficult to define accurately and is omnipresent. This structural mixing of audiences, combined with the public visibility of evaluation metrics, forces athletes into a state of permanent scrutiny. Furthermore, this public quantified evaluation inevitably activates the social comparison mechanism (Festinger, 1954). When negative evaluations or superior data of others are made public online, athletes must not only process the informational pressure of the evaluation itself but also endure the cognitive pressure of having the public witness their setbacks. This continuous, insecure, and permanent scrutiny significantly depletes psychological resources, leading athletes to doubt their own abilities and consequently weakening their self-efficacy (Kernis, 2003; Edmondson, 1999).

Second, according to Sunstein's (2017) definition, group polarization refers to the phenomenon where group members, after deliberation, move toward a more extreme point in the direction of their initial tendency. On the internet, driven by a one-sided argument pool and the confidence enhancement brought by peer corroboration, the interaction of like-minded individuals leads opinions not to converge toward the center but to radicalize in a single direction. In the new media

environment, algorithmic recommendation mechanisms tailor information flows for each user, continuously pushing content that matches existing preferences, resulting in objective corrective information being invisibly filtered out and homogenized negative emotions being infinitely amplified (Pariser, 2011). For athletes, this means a single mistake may trigger cybercascades, where netizens abandon independent judgment of facts and instead blindly follow group signals, leading to an explosion of negative evaluations and forming an irrational and aggressive public opinion field (Pariser, 2011; Sunstein, 2017). In this polarized atmosphere, online anonymity lowers individual morality, transforming extreme negative emotions into aggressive behaviors rarely seen in real life, namely cyberbullying (Suler, 2004). This overwhelming malice not only directly harms athletes' self-esteem but also shakes their sense of self-worth through frequent social comparison and negative evaluation, damaging their mental health (Lin et al., 2025; Mountjoy & Edwards, 2022).

It is worth noting that the destructive power of this high-intensity evaluative and polarized environment constructed by new media is significantly amplified when placed within the context of Chinese culture (Xu & He, 2025). In the context of China's unique Shame Culture and collectivism, individuals are highly sensitive to external evaluations because these concern not only personal dignity but also the harmony of social relationships and the maintenance of Face. Research indicates that these cultural traits cause negative feedback on the internet to be internalized into a more intense fear of negative evaluation, leading individuals to be more prone to a total collapse of self-worth when facing public criticism, rather than viewing it merely as an accusation against a specific behavior (Zhang et al., 2022; Xu & He, 2025).

2.3 Temporal Dimension: Continuity and Inescapability

The characteristics of the new media environment in the temporal dimension are primarily manifested as the continuity and inescapability of pressure.

First, Evans's (2003) environmental stress theory points out that the key characteristic of stress lies in its continuity; that is, environmental stimuli have long-term cumulative effects and do not disappear immediately with the end of the event. This theoretical characteristic has been radically manifested in the new media context, with its technical roots lying in the concept of "Digital Memory" proposed by Mayer-Schönberger (2009). Distinct from the natural forgetting curve of human memory, cyberspace records all information by default, causing every error or instance of negative public opinion involving athletes to be permanently archived, indexed, and retrieved by the internet. This technical feature triggers a long-tail effect of public opinion pressure; that is, past mistakes may be excavated and repeatedly disseminated months or even years later, keeping athletes in a field of scrutiny for a prolonged period. For athletes, this continuity directly deprives them of the recovery space necessary for psychological restoration. According to Attention Restoration Theory, individuals need to periodically detach from environments requiring high directed attention and enter low-stimulus environments to restore cognitive resources (Kaplan & Kaplan, 1989). However, the continuous operation and around-the-clock push notifications of the new media environment break the boundary between competition and rest, leading to athletes' inability to truly disconnect from stressors (Pacewicz & Mellano, 2024). This sustained external high pressure causes athletes' psychological resources to be chronically depleted without replenishment, thereby inevitably exacerbating job burnout (Zhang & Yu, 2025). Its specific symptoms manifest as emotional exhaustion, sport devaluation (reduced identification with the value of sport), and a significantly reduced sense of accomplishment (Maslach et al., 2001; Pacewicz & Mellano, 2024; Raedeke, 1997).

Second, inescapability refers to the fact that the new media environment breaks the isolation of physical space, forming a pervasive and permeable pressure (Ballouli & Sanderson, 2012). Even if athletes actively adopt avoidance strategies, such as uninstalling social media apps, public opinion pressure still permeates their lives through real-world interpersonal networks, transmitting stress (David et al., 2018). This environmental characteristic deprives athletes of their sense of control over information reception. When individuals discover that no matter what actions they take, they cannot block the intrusion of negative information, learned helplessness arises (Seligman, 1975). Relevant research indicates that this perceived uncontrollability of the environment is an inducer of negative emotions; it forces individuals to remain in a defensive state for extended periods, thereby significantly increasing the risk of anxiety and depression (Chorpita & Barlow, 1998).

It is worth noting that this temporal pressure is further amplified within the Chinese cultural context. On the one hand, based on the social structure of the "Differential Mode of Association" (Chaxu Geju) in Chinese society, family members and close

friends are highly involved in interpersonal networks, leading to blurred boundaries between public and private spheres. This makes it difficult for athletes to build defenses against public opinion in their private domains (Fei, 1948/1992). On the other hand, the concept of Shendu (watchfulness over oneself when alone) in traditional Chinese culture emphasizes internal self-restraint. In the new media environment, this cultural concept can evolve into a high-intensity self-surveillance mechanism. Even in moments without supervision, athletes may remain in a state of constant nervous tension due to internalized moral anxiety (Warren & Zurawski, 2014). Furthermore, Chinese society generally holds expectations of moral perfection for public figures, making historical mistakes harder for the public to forgive and forget (Bedford & Hwang, 2003). The persistence of this moral stain often forms a psychological shadow that is difficult to dissipate, thereby further hindering athletes' psychological recovery.

3. Discussion

Based on the perspective of environmental psychology, this study has analyzed the impact of the physical, social, and temporal characteristics of the new media environment on athletes' mental health. Through reasoning across the aforementioned three dimensions, the study finds that new media has evolved from a single medium of information dissemination into a complex environmental system. This system constructs high-intensity stimuli of immediate presence, polarized public evaluation, and persistent permeable pressure, causing negative impacts on individual psychology. On this basis, the discussion will further explore how physical, social, and temporal characteristics interact to form a cyclical pressure field and elucidate the theoretical value of the environmental psychology perspective in analyzing the unique psychological dilemmas of Chinese athletes.

3.1 Synergistic Effects of Multidimensional Characteristics: Constructing a Cyclical Pressure Field

Previous studies have mostly examined the impact of single factors (such as cyberbullying or information overload) in isolation, but this study indicates that the physical, social, and temporal dimensions of the new media environment are functionally interdependent, jointly constructing a cyclical environmental pressure system.

First, the physical dimension provides the structural basis and propagation conditions for the generation of pressure. The high intensity and immediate presence of information dissemination enable massive amounts of information to cover athletes' perceptual range within an extremely short time. This immediate connectivity at the physical level directly serves the operational mechanism of the social dimension by accelerating the information feedback loop. Specifically, algorithms in the social dimension do not merely present information passively but continuously infer user preferences based on click and browsing history, thereby constructing a unique, exclusive information space for each user. Under this personalized filtering mechanism, algorithms prioritize pushing content that confirms users' existing views while filtering out challenging information. Then, the interaction between the high-speed propagation of the physical dimension and the closed filtering of the social dimension leads to the outbreak of "cybercascades" within a short period. For example, when negative evaluations against athletes appear, algorithms quickly capture and reinforce this emotional signal within the closed information environment, facilitating rapid dissemination across the entire network. In other words, without the high-speed propagation channel provided by the physical dimension, those homogenized negative evaluations in the social dimension would be difficult to aggregate into an overwhelming scale effect within an extremely short time.

Second, negative evaluations in the social dimension are transformed into long-term psychological burdens through the temporal dimension. Group polarization pointed out by Sunstein and the online disinhibition effect proposed by Suler jointly constitute the generation mechanism of aggressive content. First, group polarization promotes the radicalization of negative emotions through the argument pool of homogenized groups and peer corroboration effects. Second, relying on anonymity, the online disinhibition effect weakens individual moral constraints and releases aggressive impulses repressed in real life. However, this aggressive content generated by these mechanisms does not dissipate with the end of the event but is retained by the "Digital Memory" characteristic of the temporal dimension. Finally, the default persistent storage and low-cost retrieval functions of cyberspace deprive content of the right to be forgotten, turning social evaluations that might have appeared briefly into a permanently existing, hard-to-remove label.

Therefore, these three dimensions jointly constitute a cyclical pressure system that evolves from generation to enhancement

and finally to solidification. Physical characteristics facilitate the immediate arrival and overload of stressors; social characteristics shape the polarization and aggressiveness of stressors; and temporal characteristics solidify the long-term existence and inescapability of stressors. This systemic environmental characteristic keeps athletes in a psychological state of high cognitive load and low sense of control for extended periods, thereby increasing the risk of impaired mental health.

3.2 Theoretical Value of the Environmental Attribution Perspective

This study introduces Gifford's environmental psychology framework; its core theoretical value lies in supplementing the environmental attribution perspective on athletes' mental health issues (Gifford, 2014). Traditional competitive sports psychology research mostly focuses on attribution at the individual level, paying attention to athletes' resilience, emotion regulation strategies, or personality traits. However, this perspective has limitations when explaining psychological crises in the new media environment. This study finds that the new media environment itself possesses objective attributes that induce psychological problems. Its unique three-dimensional stimulus characteristics pose a severe challenge to athletes' existing psychological adaptation systems, causing systematic excessive consumption of individual cognitive resources and psychological defense mechanisms. Based on this, the introduction of the environmental perspective has significant practical significance. It redefines athletes' psychological crises as objective stress responses of individuals coping with specific environmental pressures, rather than subjective defects in individual capabilities. It emphasizes that in future mental health interventions, equal importance must be attached to the pathogenic impact of environmental factors.

4.Recommendations

The core practical implication of this study is that protecting athletes' mental health must transcend the paradigm of purely individual intervention and shift towards systemic governance at the environmental level. This requires building a comprehensive management system covering platform technology, organizational institutions, and social culture. First, at the level of technological and legal governance, social media platforms should assume primary responsibility by optimizing algorithmic recommendation mechanisms to interrupt the spread of extreme emotions and by establishing efficient mechanisms for monitoring and intervening in cyberbullying. Simultaneously, at the legal level, it is necessary to clarify the consequences of infringement and cyberbullying, using clear clauses to constrain the boundaries of speech and protect athletes' privacy. Second, at the level of organizational support, sports management departments should establish a proactive psychological support system. This system should not only provide professional public opinion management and legal aid but also guarantee athletes' rest time within the competitive environment, ensuring that athletes have sufficient safe time for the restoration of psychological resources. Finally, at the cultural level, public opinion urgently needs to reflect on the excessive expectations of moral perfection for athletes. By cultivating a rational, inclusive, and humanistic sports culture, the professional environment for athletes can be improved at its root.

5.Limitations and Future Directions

Although this study constructs a theoretical model of the impact of new media on athletes' mental health from the perspective of environmental psychology, certain limitations remain. This study is primarily based on literature review and theoretical deduction, lacking support from empirical data. Additionally, it focuses on analyzing the pathogenic characteristics of the environment, with insufficient exploration of individual psychological resilience during the coping process and the potential social support functions of new media. Future research can develop in the following directions. First, conduct longitudinal studies to quantify the dynamic relationship between the duration of new media usage, the intensity of public opinion, and athletes' mental health status. Second, deepen cross-cultural comparative research to contrast the differences in psychological reactions to cyberbullying between athletes in collectivist and individualist cultural backgrounds, further clarifying whether the concept of Face plays a specific effect in the process of stress transmission.

6.Conclusion

Based on the perspective of environmental psychology, this study analyzes the mechanisms through which the new media environment influences athletes' mental health. The study finds that new media has evolved into a complex environmental system, jointly constructing a closed-loop space of cyclical pressure targeting athletes across three dimensions: physical,

social, and temporal. Specifically, the high intensity and immediate presence of the physical dimension provide the foundation for pressure propagation, significantly increasing cognitive load (Hilbert & López, 2011). The generalized evaluation and group polarization of the social dimension create an aggressive field of public opinion, destabilizing athletes' sense of self-worth (Sunstein, 2017). Furthermore, the Digital Memory and inescapability of the temporal dimension transform instantaneous shocks of public opinion into lasting psychological exhaustion (Mayer-Schönberger, 2009). It is worth noting that within the unique cultural background of China, collectivist values and Shame Culture further amplify the negative impacts of the aforementioned environmental characteristics, facilitating a trend where social evaluation fear becomes internalized into the individual's deep psychological structure (Xu & He, 2025).

The core contribution of this study lies in conceptualizing new media as an independent environmental system and constructing a theoretical framework linking environmental characteristics to psychological outcomes. The study emphasizes that protecting athletes' mental health requires not only enhancing individual psychological resilience but, more importantly, implementing normative constraints at the environmental level. Through multi-level interventions such as platform management, legal protection, and cultural guidance, negative environmental stimuli can be mitigated to create a safe environment.

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Research on the Development and Teaching Application of Practical Case Studies in the International Settlement Course

Yongdong Xu, Xiaoyan Wang*

School of Economics and Management, Guangdong Technology College, Zhaoqing, 526100, China

*Corresponding author: Xiaoyan Wang

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Abstract: As the process of global economic integration deepens, international settlement—a core component of international trade and financial activities—has assumed increasing significance. However, current university teaching of the International Settlement course commonly suffers from issues such as a disconnect between theory and practice, monotonous teaching methods, and students' weak application skills. This paper aims to explore a systematic model for developing practical case studies and integrating them into teaching to enhance course quality and students' practical capabilities. The research first analyses the current state and challenges of the International Settlement course. Subsequently, multi-tiered, scenario-based practical cases are designed around core knowledge points including interbank transactions, international settlement system operations, bills of exchange, cheques, remittances, collections, letters of credit, bank guarantees, standby letters of credit, financing operations, and commercial invoicing. Finally, the paper proposes a teaching application strategy integrating case-based teaching, project-driven learning, and simulation training, alongside establishing a diversified assessment system. Findings indicate this model effectively stimulates student engagement, deepens theoretical comprehension, and significantly enhances their ability to analyse and resolve practical international settlement issues. It offers valuable insights for cultivating versatile finance and trade professionals suited to contemporary demands.

Keywords: International Settlement; Practical Teaching; Case Development; Teaching Application; Financial Talent Cultivation

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Introduction

Against the backdrop of the ongoing advancement of the Belt and Road Initiative and profound transformations in the global trade landscape, international settlement serves as the financial bridge connecting parties in cross-border transactions. The standardisation, security, and efficiency of its operations directly impact the smooth conduct of international trade. International settlement not only involves complex financial instruments and diverse payment methods but also presents challenges stemming from varying national laws and regulations, international conventions, and exchange rate risks. Consequently, it imposes exceptionally high demands on practitioners' professional knowledge, operational skills, and risk awareness. As the primary arena for talent cultivation, the quality of teaching in the International Settlement course at higher education institutions directly determines the professional calibre of future practitioners.

However, traditional teaching models for International Settlement often prioritise theoretical knowledge transmission, with

teacher-centred ‘lecture-style’ approaches being prevalent. Students may learn about the negotiability of bills of exchange, the ‘strict compliance’ principle of letters of credit, and the distinctions between ‘D/P’ and ‘D/A’ collections in class. Yet, when confronted with real-world business scenarios, they frequently find themselves at a loss. A formidable gap persists between theoretical knowledge and practical application. Students may recognise a bank guarantee yet remain unclear on how to apply for a tender guarantee for a specific construction bid; they may recite UCP600 clauses but struggle to identify critical points when reviewing letter of credit documentation. This state of learning – knowing the what but not the why – severely hampers the development of students’ professional competencies.

To resolve this pedagogical dilemma, reforming practical teaching is imperative. The case study method, a teaching approach that tightly integrates theoretical knowledge with real-world problems, has been widely applied in fields such as law and business studies with notable success. By presenting authentic or simulated scenarios, it guides students to apply learned theories through analysis, discussion, and decision-making, thereby deepening understanding and honing skills through ‘learning by doing’. The research objective of this paper is to systematically develop a series of practical cases covering core knowledge points, grounded in the intrinsic requirements of the International Settlement course. It further explores effective application strategies for these cases within classroom teaching, aiming to construct a new teaching model that deeply integrates theory and practice. This endeavour seeks to provide a viable solution for enhancing the teaching effectiveness of the International Settlement course.

1. Current State and Challenges in Teaching the International Settlement Course

Before delving into case development and application, it is essential to clearly recognise the prevalent issues and challenges currently facing the teaching of the International Settlement course.

1.1 Disconnect Between Theory and Practice, Rigid Teaching Content

Presently, most International Settlement textbooks feature rigorous systems and detailed theoretical exposition, yet their content updates lag behind developments in international financial practice. For instance, textbooks devote substantial coverage to traditional settlement methods while offering limited coverage of cutting-edge topics such as digital settlement platforms (e.g., SWIFT gpi) and blockchain applications in trade finance. Instructors often structure lessons around textbook chapters, resulting in students mastering ‘textbook international settlement’ rather than ‘practical international settlement.’ Students can recite the four fundamental parties involved in remittances but cannot simulate a genuine cross-border wire transfer operation; they understand the basic letter of credit process yet lack intuitive comprehension of how banks internally examine documents or handle discrepancies.

1.2 Monotonous Teaching Methods and Low Student Engagement

Despite widespread multimedia adoption, many classrooms remain fundamentally linear knowledge-transfer environments reliant on PowerPoint presentations and blackboard notes. Teachers lecture while students listen, lacking effective interaction and deep engagement. This one-way information flow struggles to stimulate student interest or initiative. Particularly when explaining dry legal provisions and operational details like bill of exchange behaviour or bank guarantee clauses, students easily become bored and confused, significantly diminishing learning outcomes. Classrooms lack elements that engage students actively, leaving their minds in a passive receptive state. Critical thinking and problem-solving abilities remain underdeveloped.

1.3 Assessment Methods Are One-Sided, Lacking Competency Focus

Course assessments predominantly rely on end-of-term closed-book examinations, with question types emphasising conceptual differentiation, short answers, and essays. While this format tests students’ recall of theoretical knowledge, it struggles to effectively evaluate their ability to apply that knowledge to solve practical problems. A student may achieve high marks in examinations yet prove error-prone when reviewing documentation under a letter of credit due to lacking practical experience. The evaluative system’s ‘command stick’ effect directs students’ focus towards ‘memorising exam points’ rather than ‘practising skills,’ running counter to the objective of cultivating applied and versatile professionals.

1.4 Lack of Systematic Practical Case Resources

Although some lecturers incorporate case studies into teaching, these examples are often fragmented and isolated, lacking

systematic coherence and progression. One case might address a single risk point in collections, while another might explain an isolated clause of a letter of credit. Students struggle to construct a comprehensive, coherent understanding of international settlement through such fragmented examples. Moreover, many cases are overly simplified, falling far short of the complexity encountered in real commercial environments. Consequently, they fail to adequately hone students' ability to make integrated decisions under conditions of incomplete information, time pressure, and the intertwining interests of multiple parties.

In summary, the teaching reform of the International Settlement course is urgently needed. Developing a systematic, comprehensive, and practical case repository, alongside exploring corresponding teaching methodologies, represents a crucial breakthrough in addressing the aforementioned issues.

2. Systematic Development of Practical Case Studies for the International Settlement Course

In response to the aforementioned teaching challenges, we have designed a multi-tiered, scenario-based practical case study framework covering the core knowledge points of the course. This framework aims to guide students in translating theoretical knowledge into practical operational skills by simulating authentic business scenarios.

2.1 Principles for Case Development

Authenticity Principle: Case backgrounds, business processes, and document formats shall be derived from genuine international business practices wherever possible, or reasonably adapted from real transactions to ensure high simulation fidelity.

Systematic Principle: Case design shall encompass all core aspects of international settlement—from foundational banking relationships and settlement system operations, through specific settlement instruments and methods, to financing and risk control—forming a comprehensive knowledge network.

Progressive Principle: Case difficulty escalates from straightforward single-concept scenarios to integrated, complex cases, progressively enhancing students' analytical capabilities and decision-making proficiency.

Problem-Oriented Principle: Each case presents a clearly defined problem requiring resolution, such as 'As an exporter, which settlement method should you select to mitigate risks?' or 'As a bank's document reviewer, what discrepancies have you identified? How should they be addressed?', thereby guiding students towards proactive critical thinking.

2.2 Core Practical Case Design

2.2.1 Infrastructure and Tools Cases

Case One: Interbank Transactions and Correspondent Banking Relationships

Scenario: A local commercial bank in China, Bank A, wishes to process a US dollar remittance to Nigeria for its client. However, Bank A has no branches in Nigeria.

Core Task: Students, acting as staff within Bank A's international operations department, must design a complete remittance pathway. This involves researching and selecting a suitable correspondent bank (e.g., an international major bank, Bank B, with extensive networks in Nigeria), explaining the agreements required to establish the correspondent relationship (e.g., the Account Relationship Agreement), and simulating the dispatch of a SWIFT MT202 message to initiate the interbank funds transfer instruction.

Learning Objectives: Enable students to understand the correspondent banking system as the cornerstone of international settlements, and master the fundamental logic and communication methods^[1] for interbank fund transfers.

Case Study 2: Operational Flow of International Settlement Systems – Using the SWIFT System as an Example

Scenario: Simulate the complete process of a letter of credit payment from a German exporter to a Chinese importer.

Core Task: Students assume distinct roles (importer, issuing bank, advising bank, exporter) within a simulated SWIFT environment. They must identify and explain the key message types (e.g., MT700, MT710, MT734, MT754) and their core content at each stage (opening, advising, document presentation, payment/acceptance).

Learning Objectives: To provide students with an intuitive understanding of the SWIFT system's role as the 'nervous system' in international settlements, and to appreciate the importance of standardised messages in enhancing efficiency and mitigating risks^[2]

Case Study Three: The ‘Life Cycle’ of Negotiable Instruments – Application of Bills of Exchange and Cheques

Scenario: Chinese exporter A exports goods to US importer B under a contract stipulating deferred payment against documents (D/A 60 days after sight). Concurrently, Company A’s finance department must issue a cheque to settle payments with a local supplier.

Core Tasks: (1) Require students to correctly prepare a draft based on the D/A 60-day transaction context, simulating the exporter’s ‘issuance’, the importer’s “acceptance”, and subsequent ‘payment’ upon maturity. (2) Provide a cheque sample for students to identify mandatory entries, comparing its similarities and differences with bills of exchange and promissory notes.

Learning Objectives: Master bill of exchange preparation and key negotiable instrument actions; understand cheques’ application in domestic settlements; clearly distinguish the legal characteristics and uses of these three fundamental negotiable instruments ^[3]

2.2.2 Core Settlement Method Case Studies

Case Study 4: The Risk Dynamics of Remittance and Collection

Scenario: A newly established Chinese export company receives simultaneous orders from buyers in two different countries. Buyer A (a long-standing, reputable client) proposes T/T payment: 30% advance, 70% balance against copy of bill of lading. Buyer B (from an emerging market, first-time transaction) requests D/P at sight.

Core Task: As the company’s sales manager, analyse risk points under both settlement methods and propose risk control measures for each transaction. For instance: For T/T, how to verify payment receipt? For D/P, how to select a collecting bank and control title to goods?

Learning Objectives: Gain a profound understanding of the limitations of commercial credit; master the distribution of risks between buyer and seller under remittance and collection methods; and develop the ability to make preliminary settlement method selections based on customer creditworthiness and transaction context.

Case Study V: ‘Document Trading’ in Letters of Credit – Practical Application of UCP600

Scenario: Provide a complete letter of credit (containing complex soft clauses) and a full set of corresponding documents (commercial invoice, bill of lading, insurance policy, packing list, certificate of origin, etc.), deliberately incorporating several discrepancies (e.g., invoice amount mismatching the credit, bill of lading indicating late shipment, inadequate insurance coverage).

Core Task: Students assume the role of an exporter’s documentation clerk. Within a stipulated timeframe, they must examine the documents, identify all discrepancies, and propose feasible remedial actions in accordance with international practices such as UCP600 and ISBP. These may include amending documents, issuing a supplementary or supplementary bill of lading, or authorising the bank to dispatch documents and make payment/acceptance against a guarantee.

Learning Objectives: This constitutes the core case study of the course. It aims to train students to ‘think like a bank’, mastering the principle of ‘strict compliance’ under letters of credit, enhancing practical document review skills and risk management capabilities ^[4]

2.2.3 Guarantee and Financing Cases

Case Six: The ‘Guarantee’ Function of Bank Guarantees and Standby Letters of Credit

Scenario:

- (1) A Chinese engineering company is bidding for a major infrastructure project in a Southeast Asian nation and must submit a tender bond to the tenderer.
- (2) A Chinese importer procures large-scale equipment from an American exporter, who requires the Chinese party to provide a standby letter of credit as security for its instalment payments.

Core Tasks: (1) Students are required to draft key clauses for the engineering company’s tender bond (e.g., guarantee amount, validity period, claim conditions). (2) Compare and analyse the similarities and differences between standby letters of credit and bank guarantees in terms of legal attributes, applicable conventions (URDG758 vs. ISP98), and operational practices.

Learning Objectives: Understand the guarantee function of bank guarantees and standby letters of credit as contingent liabilities; master their fundamental types and application scenarios; and develop the ability to undertake preliminary clause

design ^[5].

Case Study 7: Financing Operations in International Settlement

Scenario: A small-to-medium-sized exporter, Company C, has secured a substantial overseas order but faces funding constraints when procuring raw materials. Concurrently, it requires early liquidity for a held deferred acceptance draft (D/A 90 days).

Core Task: Students are required to devise a financing solution for Company C. The proposal should include: Utilising packing credit facilities during order execution; Monetising accounts receivable post-shipment through export discounting or forfaiting.

Students must compare the costs, risks, and operational procedures of different financing methods.

Learning Objectives: Understand the integral relationship between international settlement and trade finance; Master the characteristics and applicability of mainstream trade finance products; Develop foundational capabilities to provide comprehensive financial solutions for enterprises ^[6].

2.2.4 Basic Documents and Comprehensive Case Studies

Case Study 8: The ‘Core’ Role of Commercial Invoices and Comprehensive Application

Scenario: Provide a complete CIF trade contract background, requiring students to prepare a full set of settlement documents as the exporter.

Core Task: The commercial invoice forms the core of the entire documentation set. Students must first accurately prepare the commercial invoice according to contract and letter of credit requirements, ensuring precise descriptions, amounts, terms, etc. Subsequently, using the invoice as the foundation, prepare or review other relevant documents (such as the bill of lading, insurance policy, packing list, and draft) to ensure consistency between each document and between documents and the underlying transaction.

Learning Objectives: Reinforce the central role of the commercial invoice in multiple functions including title transfer, payment settlement, and customs clearance. Through comprehensive document preparation exercises, integrate previously acquired fragmented knowledge points to develop complete operational proficiency ^[7].

3. Teaching Application Strategies for Practical Cases

A meticulously developed case repository serves merely as the ‘ammunition’ for teaching reform. How effectively this ammunition is ‘fired’ in the classroom determines the success or failure of the reform. We propose the following three complementary teaching application strategies.

3.1 Deep Application of the Case Method

The case method is by no means a simple ‘storytelling exercise’. Its successful implementation relies on careful instructional design.

Pre-class Preparation: Instructors distribute case materials to students in advance, accompanied by guiding questions. Students must undertake preparatory study individually or in groups, consulting relevant resources (such as the original UCP600 text) to formulate preliminary analytical approaches.

Classroom Discussion: The classroom serves as the primary arena for case-based teaching. The instructor should adopt the role of a ‘director’ rather than a ‘performer,’ employing questioning, probing, and debate facilitation to stimulate profound student reflection. For instance, in the letter of credit case, follow-up questions might include: ‘What might be the underlying intent behind this “soft clause”?’ or ‘If you were the bank, would you accept this discrepancy? Why?’ Students are encouraged to adopt the perspectives of different stakeholders (exporter, importer, bank) through role-swapping exercises.

Synthesis and Elevation: Following discussions, instructors must deliver incisive summaries. This entails not merely providing ‘standard answers’ to questions, but distilling the universal principles, analytical frameworks, and decision-making logic embedded within the case. This facilitates students’ cognitive leap from ‘case-specific analysis’ to ‘general principles’ ^[8].

3.2 Integration of Project-Based Learning and Role-Playing

For comprehensive, complex case studies, the Project-Based Learning (PBL) approach may be employed.

Project Design: A large-scale case study (e.g., ‘Simulating the Full Process from Inquiry to Receipt of Payment’) is

established as a term-long project, broken down into several sub-tasks (e.g., selecting settlement methods, drafting contracts, reviewing letters of credit, preparing documentation, applying for financing).

Role-Playing: Divide students into groups, each assuming distinct roles such as exporter, importer, exporting bank, and importing bank. Groups progress through project milestones by fulfilling their respective responsibilities and engaging in interactions. For instance: the exporter group submits a letter of credit application; the importing bank group issues the credit; the exporting bank group provides notification; and the exporter group prepares and submits documents.

Process Assessment: Instructors conduct formative evaluations of each group's performance throughout project phases, assessing teamwork, communication skills, and problem-solving abilities. This approach significantly enhances student engagement and immersion, transforming the learning process into a quasi-professional work experience.

3.3 Supplementary Simulation Training and Digital Platforms

Following theoretical study and classroom discussions, simulation training is essential to consolidate and validate learning outcomes.

Introduction of Teaching Software: Utilising international trade and finance simulation training software, students execute a complete international settlement transaction within a virtual environment. The software automatically assesses the accuracy of student operations and provides immediate feedback.

Digital Case Library: Developed case studies are digitised and integrated into an online learning platform. This platform incorporates case texts, scanned copies of relevant documents, instructional videos, online quizzes, and discussion forums, offering students resources for self-directed and extended learning.

Flipped Classroom Implementation: Students complete theoretical knowledge acquisition and foundational case analysis via the online platform prior to class. Classroom time is then dedicated entirely to advanced discussions, project collaboration, and problem-solving, maximising teaching efficiency.

4. Establishing a Diversified Assessment Framework

Reforming teaching methodologies must be accompanied by corresponding changes to assessment systems to genuinely guide students from exam-oriented learning towards practical application. We propose establishing a diversified assessment framework integrating process and outcome, knowledge and competency.

4.1 Formative Assessment (40%)

Class Participation (15%): Evaluates the quality of contributions, engagement, and teamwork during case discussions and role-play exercises.

Modular Assignments (25%): Each core module includes a practical assignment (e.g., drafting a promissory note, reviewing a letter of credit, drafting guarantee terms), focusing on procedural compliance and accuracy.

4.2 Summative Assessment (60%)

Comprehensive Case Analysis Report (30%): Students complete a novel, complex case analysis report in groups by term's end. The report must include problem identification, solution design, risk assessment, and decision rationale, comprehensively evaluating their integrated application skills.

End-of-Term Computer-Based Simulation Examination (30%): A timed practical examination conducted on simulation software, requiring students to complete the entire workflow of a designated transaction within the allotted time. The system provides automatic scoring, primarily assessing operational proficiency and accuracy.

This assessment framework integrates evaluation throughout the learning process, focusing not only on students' mastery of theoretical knowledge but also on their ability to translate knowledge into practical skills. This fosters a positive feedback loop in teaching.

Conclusion

In an era where globalisation and digitalisation are intertwined, the reform of teaching the International Settlement course is no longer an "optional choice" but an "essential requirement". The research presented herein, focusing on the development and pedagogical application of practical case studies, constitutes a proactive response to this contemporary imperative. By

constructing a systematic, multi-tiered, and contextualised case repository, complemented by diversified teaching strategies such as case-based instruction, project-driven learning, and simulation-based training, alongside a corresponding assessment framework, we can effectively transcend the limitations of traditional teaching methods. This approach builds a robust bridge connecting theoretical knowledge to practical application.

Practice demonstrates that this novel approach significantly enhances students' engagement and classroom participation. Within highly realistic business scenarios, learners gain profound insights into the complexities and risks of international settlements, master operational essentials of diverse settlement instruments and methods, and develop preliminary integrated problem-solving capabilities. This proves crucial for cultivating high-calibre, versatile professionals in international finance and trade—individuals who possess both theoretical knowledge and practical skills, adhering to regulations while demonstrating adaptability.

Naturally, both the case repository and teaching methodology warrant ongoing refinement. Future enhancements may include incorporating cutting-edge topics (such as digital currencies and supply chain finance), strengthening corporate partnerships to develop authentic cases, and leveraging VR/AR technologies to heighten simulation immersion. Regardless, adhering to a student-centred, competency-driven approach remains the fundamental pathway to elevating the teaching quality of International Settlement and, indeed, the broader business education landscape.

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Application Analysis of Psychological Training in Tennis Teaching of Young Athletes

Qian Wang¹, Zhenpeng Yuan¹, Yuchen Guo^{2*}

1.Belarusian State University of Physical Education, Minsk 220020, Belarus

2.Department of Global Convergence, Kangwon National University, Chuncheon-si 24341, South Korea

*Corresponding author: Yuchen Guo, guoyuchen2024@163.com

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Abstract: This paper systematically discusses the application value and implementation path of psychological training in tennis teaching for young athletes. This paper first expounds the theoretical basis of psychological training, including Pavlovian conditioning theory and its application in suggestion training, and analyzes the characteristics and common methods of psychological training. Secondly, the common types of psychological problems in adolescents and their manifestations are summarized, and the psychological advantages of adolescent athletes in terms of achievement motivation, emotional regulation, self-confidence and learning ability are pointed out. On this basis, combined with the characteristics and difficulties of tennis teaching, the specific application strategies of psychological training in tennis teaching are proposed, including attention training, emotional regulation, goal setting and psychological counseling. Furthermore, the positive effects of psychological training on improving the success rate of serve and the stability of receiving and receiving are verified through empirical research data. Finally, this paper analyzes the challenges faced by psychological training in tennis teaching, such as insufficient teachers, tight classroom time and difficulty in integrating training forms, and looks forward to the future development trend of psychological training in tennis teaching.

Keywords: Psychological Training; Junior Athletes; Tennis Teaching; Emotional Regulation; Attention Training

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1.Theoretical basis of psychological training

1.1 What is psychological training?

Psychological training refers to the process of shaping and optimizing the psychological state and psychological quality of athletes or students through systematic and purposeful interventions, aiming to make positive changes in their psychological characteristics to meet the needs of specific sports situations, so as to better adapt to the requirements of sports competitions or special tests ^[2]. In essence, psychological training is an educational process based on psychological theories and methods, which uses psychological professional knowledge and technology to exert directional influence on the psychological activities and external behaviors of trainees to solve the psychological problems they face in training and competition, and improve their psychological adaptability and competitive performance level ^[5].

As a specific application of psychological training in the field of competitive sports, sports psychology training not only focuses on the improvement of athletes' competitive performance and the stable performance of their on-the-spot state, but

also pays more attention to the maintenance of their mental health and the cultivation of psychological regulation ability. This process emphasizes that under the guidance of scientific theory, through planned and step-by-step systematic training, athletes can master a series of psychological regulation strategies and enhance their self-awareness and emotional management ability, so as to achieve the effective development of psychological resources and the full release of competitive potential^[1].

On the basis of theory, Pavlov's conditioned reflex theory provides an important basis for suggestion training. He pointed out that suggestion training essentially acts on people's higher neural activity through language, that is, the second signaling system, to regulate the excitation and inhibition processes in the cerebral cortex, and then affect the physical and psychological state of the individual^[6]. This mechanism suggests that language stimulation has a special directed guidance role in mental training. Therefore, in the process of implementing psychological training, we should not only pay attention to general psychological counseling and cognitive reconstruction, but also pay attention to the psychological strengthening of specific words, so that they can be effective signal carriers to regulate psychological state and stimulate positive behavioral responses. This psychological anchoring technique at the lexical level helps to awaken the positive state of athletes at critical moments and improve the pertinence and effectiveness of their psychological preparation.

1.2 Characteristics and methods of psychological training

As an important part of the sports psychology system, psychological training has a series of distinct disciplinary characteristics and relies on a variety of scientific methods to implement, and psychological training emphasizes individualized differences. Due to the significant differences in psychological traits, emotional regulation ability, and cognitive style between different athletes, training programs need to be designed based on individual assessment to achieve aptitude teaching^[11]. This principle embodies the practical application of the "person-centered" approach in psychology. Secondly, psychological training is dynamic in time periods. At different stages, the focus of training is also different, and the focus is on cultivating judgment ability and team cohesion during daily training. The pre-competition stage focuses on enhancing positive emotional experience and optimizing psychological state to improve the stability of competitive performance. This phased arrangement reflects the systematic and situational dependence of the training process.

Psychological training has cognitive reconstruction. This training can help athletes establish more adaptive cognitive patterns, allowing them to quickly identify key information in complex competition situations, strengthen task memory and logical levels, and improve the efficiency of information processing. Psychological training also has the function of decision optimization. Through continuous attention training, athletes can maintain the effective allocation of cognitive resources in high-stress situations, improve the timeliness and accuracy of judgment and decision-making, and grasp key opportunities in competitions.

In the method system of psychological training, the following methods are widely used:

Goal-setting training: This method provides clear guidance for athletes' training and competition behavior by helping them set specific, measurable, and challenging goals. A reasonable goal system can not only enhance the level of motivation, but also help to decompose macro goals into actionable training tasks, thereby improving the systematization and evaluability of training.

Positive self-suggestion and confidence building: In the face of anxiety and self-doubt in competitions, suggestion training and confidence building techniques can be used. Pavlov's conditioned reflex theory points out that language, as a second signaling system, can regulate central nervous system activity, which in turn affects behavioral performance. By designing positive language cues and matching emotional regulation strategies, athletes can be more resilient and able to respond to challenges with a more stable mindset.

Attention control training: Attention is the core cognitive resource of competitive performance. The training improves athletes' ability to maintain concentration in high-pressure environments through scenario simulation, distraction elimination, and concentration tasks, and avoids decision-making errors caused by distraction.

Stress regulation training: Sports competitions are often accompanied by high psychological pressure. Drawing on Mayo Clinic's stress management strategies, such as meditation, breathing training, positive visualization and body relaxation, can effectively reduce athletes' physical arousal levels and improve their nervousness and fear during competition.

Construction of Code of Conduct and Psychological Contract: By establishing a clear code of conduct and team norms, and integrating the theory of “psychological contract”, a common understanding of behavioral expectations and value orientation can be established between athletes and coaches. This method not only helps to create a good team psychological atmosphere, but also motivates athletes to form a sense of self-supervision, thereby promoting the long-term stable development of their psychological state.

2. Analysis of the types, manifestations and influencing factors of adolescent psychological problems

2.1 Types and manifestations of adolescent psychological problems

As a key stage of individual psychological development, adolescence has complex and diverse types and manifestations of psychological problems. Accurately grasping the core characteristics and influencing factors of adolescent psychological problems is of great significance for early identification and effective intervention^[9].

Adolescent psychological problems can be divided into the following main types according to their core symptoms: Anxiety problems usually stem from excessive worry about the situation and insufficient self-efficacy, which is characterized by persistent alertness and negative expectations of potential threats. Clinical manifestations include anxiety, sleep disturbances, excessive worry, difficulty concentrating, and physical tension^[11]. The study found that such problems are closely related to the multiple challenges faced by adolescents, such as academic pressure, social anxiety and family conflicts.

Depressive problems are mainly manifested by persistent low mood, decreased energy and loss of interest in life. Typical features include hopelessness about the future, decreased self-worth, and impaired cognitive function (eg, slow thinking, difficulty concentrating). It is worth noting that adolescent depression often presents the characteristics of “like a disease but not a disease”, that is, most of them complain of physical discomfort, and there are no obvious abnormalities in the actual medical examination.

OCD problems are characterized by recurring obsessive thoughts and/or compulsive behaviors as a core feature and manifest as an uncontrollable attachment to specific ideas or behaviors. Such problems can lead adolescents to become rigid and lead to interpersonal conflicts due to their tendency to overly intervene in the behavior of others.

Attention deficit hyperactivity disorder (ADHD) is mainly manifested by difficulty maintaining attention, behavioral impulsivity, and emotional regulation disorders. Affected individuals are often overly sensitive to environmental stimuli, and their cognitive activities are not switched at will. According to the survey data in 2022, attention deficit hyperactivity disorder is one of the most prevalent psychological disorders among children and adolescents in our country^[10].

The reversal problem is characterized by systematic resistance to authoritative norms, which is manifested in negative denial of objective requirements and significant instability of emotional regulation. Such teenagers often show strong resistance and antagonistic behavior to the educational guidance from home and school, especially critical correction.

Table 1: Main types and clinical manifestations of adolescent psychological problems

Question type	Core features	Behavioral performance
Anxious type	Excessive worry, lack of self-efficacy	Sleep disturbances, physical tension, hyper-alertness
Depressive type	Low mood, loss of interest, and a sense of hopelessness	Decreased energy, low sense of self-worth, and physical discomfort
Obsessive-compulsive type	Obsessive thinking and compulsive behavior	Stereotypical behavior and excessive interference in others
Attention deficit hyperactivity disorder	Pay attention to maintenance difficulties and impulsive behavior	Learning inattention, hyperactivity, and emotion regulation disorders
Rebellious type	Authority resists and emotions are unstable	Resist educational guidance and antagonistic behavior

2.2 Analysis of the psychological characteristics of young athletes

Youth athletes exhibit several significant advantages in terms of psychological characteristics. First of all, they generally

have a strong motivation for achievement and self-drive, can face challenges head-on in training and competitions, show high goal orientation and task persistence, tend to implement all tasks throughout, and reflect good willpower. Secondly, they usually have a relatively sound psychological regulation mechanism, which can effectively cope with the pressure of the game, quickly adjust negative emotions such as anxiety and frustration, and maintain a positive psychological state through self-motivation, so as to maintain psychological stability in a high-intensity competitive environment. In addition, adolescent athletes generally exhibit high self-efficacy. Through systematic training and repeated practice, they can gradually master complex motor skills and continuously strengthen their self-confidence in the process of improving their abilities, forming a virtuous circle of “ability-confidence”. This confidence is not only reflected in the technical level, but also in their positive perception of their potential and coping strategies. It is worth noting that the adolescent stage is in a critical period of cognitive ability and neuroplasticity development, so young athletes show strong learning and adaptability. They are able to quickly understand and internalize new tactical concepts and technical movements, and show a high sensitivity and absorption ability to coach guidance and environmental changes, which lays an important foundation for their long-term sports skill development^[8].

In summary, young athletes have obvious psychological advantages in terms of fighting spirit, emotional regulation, self-confidence and learning ability, which not only contribute to their competitive performance, but also have far-reaching significance for their personality development and psychological growth^[3].

3.Application of psychological training in tennis teaching

3.1 Characteristics and difficulties of tennis teaching

Tennis is a high-intensity confrontational sport that requires athletes to master a series of special sports skills^[7]. Therefore, tennis teaching needs to provide learners with accurate technical guidance, and standardized technical movements are the core elements that determine the performance of the game. In the teaching process, attention should be paid to students' training time and repeated practice to ensure that they form a stable movement pattern. At the same time, it is necessary to pay attention to building a teamwork mechanism, fully stimulate students' potential and technical characteristics, and jointly improve the overall training effectiveness through complementary learning and collaboration.

Tennis teaching faces the following difficulties: First, due to the individual differences in students' physical fitness, sports foundation and cognitive ability, the technical level is obviously stratified, and teachers need to achieve efficient transfer of knowledge and skills within a limited teaching cycle and formulate differentiated teaching strategies. Secondly, as a non-popular sport, most students have limited contact in daily life, and their rule cognition and skill foundation are relatively weak. Finally, the curriculum design should take into account the balance between fun and technical acquisition, while ensuring that students master standardized techniques, enhance the attractiveness of the course, so that they can not only improve their competitive ability but also gain positive sports experience during the training process.

3.2 Application of psychological training in tennis teaching

In tennis teaching, psychological training occupies an important position. It not only helps athletes better complete training tasks and improve their performance, but also helps them maintain a good psychological state, effectively cope with common psychological challenges and negative emotions, and actively regulate their performance on the field. In addition, when athletes encounter sudden psychological distress, psychological training can provide timely support and enhance their emotional regulation ability, so that they can maintain stable performance in stressful situations. At the same time, systematic psychological intervention can help reduce the frequency of bad emotions that occur during training and competition, and reduce the negative impact of emotional loss on the outcome of the game. In addition, psychological training can also promote the improvement of athletes' mental health, which has a positive effect on enhancing self-confidence and competitive level.

Combined with the characteristics of tennis teaching, concentration is a key link in training. Tennis balls are fast and hard, and there is a certain risk of sports injuries, which can cause from soft tissue contusions to more serious injuries if you do not pay attention to protection. Therefore, concentration-related psychological training should be introduced in teaching, which can not only improve students' concentration in training, but also provide a guarantee for sports safety. Secondly,

emotional regulation training is also very important. Teachers should give positive feedback in a timely manner during the teaching process, guide students to see failure as an opportunity for improvement, and motivate them to continue to invest in training. In addition, attention should be paid to the integration of physical training and mental training. Mastering tennis skills requires a lot of repetitive practice, which can not only improve students' skill level and cardiopulmonary function, but also lay the foundation for the cultivation of psychological quality. Goal-setting training is also essential. It is recommended to decompose the overall goal into several specific and feasible small tasks, and set up a reasonable feedback mechanism, such as arranging simulation competitions, so that students can get a complete practical experience and enhance the fun of teaching. For students who make mistakes in training or competition, psychological counseling should be provided in time to help them turn failure into motivation to move forward, and at the same time, it can be appropriately integrated into relaxed forms such as sports games to relieve students' tension and promote their physical and mental coordination ^[12].

4. The implementation path of psychological training in tennis training

4.1 Tennis psychological training methods

In tennis training, scientific and effective psychological training methods play an important role in improving athletes' comprehensive competitive ability. Commonly used psychological training methods mainly include the following five types:

- Psychological suggestion: refers to athletes who enhance their self-confidence through active self-suggestion before training or competition, so that their psychological state remains positive. Positive self-talk such as «I can play this ball» and «I am well prepared» can effectively regulate emotional states and help athletes cope with challenges with a more ideal mindset.
- Encourage others: Enhance athletes' self-confidence with verbal affirmation and behavioral support from peers, coaches or friends. This extrinsic motivation is especially effective for young athletes in their developmental stage, helping them build the right self-perception.
- Attention training method: Athletes maintain a high level of concentration during the game through specialized attention intensive training. In a sport like tennis, which requires quick reflexes, good attention allocation and sustained concentration are key to ensuring stable technique.
- Representation training method: With the help of verbal guidance or sound cues, repeatedly simulate and rehearse technical movements in your mind. This method strengthens action memory through psychological rehearsal, which not only helps to consolidate skills, but also achieves the effect of emotional control.
- Relaxation training: Effectively relieve tension by consciously regulating breathing rhythm and relaxing muscle groups. Deep abdominal breathing and progressive muscle relaxation are both methods that have proven effective in practice.

4.2 Application analysis of tennis psychological training

A number of research data confirm the actual effect of mental training in tennis teaching:

Example 1: Qiao Bing's research in "The Impact and Analysis of Psychological Training on the Success Rate of Tennis Sergeant" shows that in a positive state, the shooting rate of the first serve in the first zone is 73% and the second serve is 60%; The first shot in the second zone is 80%, and the second shot is 66%. In the scenario of simulating the backwardness of the game, the negative mentality led to a significant decrease in serve stability: the first serve hit rate in the first zone plummeted to 40%, and the second serve was only 26%; The first shot in the second area is 47%, and the second shot is 20%. After systematic psychological suggestion intervention, the students' serving performance improved significantly: the hit rate of the first zone increased to 93%, and the second development reached 80%; The first case in the second zone is 90%, and the second case is 70% ^[4]. This result clearly shows that negative mentality can seriously restrict athletes' technical performance, and positive psychological intervention can not only restore technical level, but even help athletes break through their self-limitations.

Example 2: Liu Yuzheng's experiment in "A Brief Discussion on Psychological Suggestion Training in Tennis Return Teaching" further verifies the effect of psychological training. The pre-test data of the experiment showed that the "unstable accuracy rate" of students receiving the serve was as high as 79.5%, while the "stability accuracy rate" was only 12.5%. After four weeks of psychological cue combined with positive prompt training, the "unstable accuracy rate" dropped significantly to 40.8%, and the "stability accuracy rate" increased sharply to 48.2%. This change shows that targeted psychological training

can effectively improve the technical stability and accuracy of athletes in the return of serves.

In addition to the above studies, other scholars have also observed similar phenomena. Zhang Hua (2022) found that a comprehensive psychological intervention combining appearance training and relaxation training can improve the accuracy of athletes' decision-making on key scores by more than 35%. These studies confirm the value and necessity of mental training in tennis from different perspectives ^[15].

Table 2 Empirical effect analysis of psychological training in tennis teaching

Research Sources and Focus	Pre-experimental data	Psychological training intervention	Post-experimental data	Effect analysis
Qiao Bing (Psychological cues affect serve)	One zone and one shot: 73% Simulated lagging behind: 40%	Systemic Suggestion Training (e.g., "I can play this ball")	One zone and one shot: 93% (in backward scenarios)	negative mentality seriously restricts the play of technology; Positive psychological intervention can not only restore level, but even help athletes break through self-limitations.
Liu Yuzheng (psychological suggestion docking serve impact)	Unstable accuracy rate: 79.5% Stability rate: 12.5%	4 weeks of psychological cue + positive cue training	Unstable accuracy rate: 40.8% Stability rate: 48.2%	Targeted psychological training can significantly improve the technical stability and accuracy of the return link.
Zhang, Hua (2022) (Impact of Comprehensive Psychological Training on Decision-Making)	Key sub-decision accuracy: baseline level	Comprehensive psychological intervention of appearance training + relaxation training	The accuracy of decision-making has increased by more than 35%	Comprehensive psychological intervention can effectively improve the quality of athletes' decision-making on high-pressure critical points.

4.3 Specific implementation strategies for psychological training

According to the psychological development characteristics of young athletes, coaches and teachers should systematically learn sports psychology knowledge, master scientific psychological training methods, and formulate personalized plans according to individual differences.

Emotional management training: Adolescents are not yet mature in their psychological development and are prone to mood swings such as irritability or nervousness during training and competitions. Teachers need to have keen observation skills to detect students with abnormal emotions in time. For irritability, individual interviews should be used to understand the specific triggers, and if necessary, family visits should be combined to explore the root cause of the problem, and psychological counseling should be comprehensively used with relaxation training and cognitive regulation. For nervousness, differentiated strategies can be adopted according to the degree and cause: for general nervousness, encouragement and psychological suggestion can be used; For severe stage fright in the game, the "siege method" can be implemented, that is, the student can be arranged to play a practice match under the watchful eyes of some students, and verbal encouragement is given, repeating 5-8 times to gradually reduce the level of competition stress. Subsequently, more practical opportunities should be created to encourage them to participate in intramural competitions and cross-team technical exchanges to consolidate the training effect in real scenarios ^[13].

Self-confidence development: For students who are afraid of failure and lack self-confidence, teachers should make good use of the combination of psychological cues and encouragement from others. Such students often set their own limits and need to break down psychological barriers through step-by-step training. In daily training, teachers should pay special attention to timely and concrete praise when they complete standardized movements or play good balls, such as "this forehand stroke is very complete" or "that shot defensive counterattack is very smart", and invite them to demonstrate and demonstrate in a timely manner. Before the inter-class competition, motivate through targeted language such as "your recent serve has improved a lot, believe in your training results"; During the competition, timely affirmation of its wonderful rounds; After winning, focus on analyzing the success factors, and if you lose, emphasize the technical highlights, avoid public criticism and mistakes, and analyze the technical problems separately after class and provide improvement plans. Through continuous technical feedback and progress affirmation, students can build solid self-confidence and gradually overcome psychological

obstacles^[14].

Increased concentration and motivation: For students with inattention and slow movements, this usually stems from insufficient motivation or interest in training. Teachers can use a combination of attention training and appearance training to first clarify the crux of the problem through in-depth communication, and then design an engaging training game. For example, the game of “catching the ball” is an effective way to train concentration: in pairs of two, one person lifts two balls flat, and the other stands 3 meters away and catches the ball before it lands for the second time. This game is not only simple and easy to play, but also improves concentration and reaction speed at the same time. If the slowness stems from psychological burden, it is necessary to channel emotions through individual conversations, or design interesting competitive games, such as group turnback running relays, to improve physical fitness and change of direction while diverting attention. In addition, setting clear short-term goals and timely feedback can also effectively stimulate students’ enthusiasm for training.

Implementation precautions: Psychological training should follow the principle of systematic, organically integrate with other technical training, rather than be carried out in isolation. Coaches need to establish student psychological files, regularly evaluate the training effect, and adjust the plan according to progress. At the same time, it is necessary to pay attention to creating a positive team atmosphere, so that psychological training and team building promote each other.

4.4 The main effect of tennis psychological training

Systematic tennis psychological training mainly improves athletes’ competitive ability from two dimensions: on the one hand, it stimulates fighting spirit and enhances self-confidence, and on the other hand, it improves concentration and execution ability. Through these trainings, athletes are able to develop a positive competitive mentality and better regulate their physical and mental state, thereby maintaining technical stability in stressful environments.

Specifically, mental training helps athletes improve in the following key aspects: first, enhance their decision-making ability and on-the-spot adaptability in the game, so that they can quickly interpret the game situation and make the best choices; secondly, improve the ability to control the rhythm of the game, whether it is leading or lagging behind, to maintain the rhythm of the game; Finally, strengthen your ability to regulate your emotions, stay calm at critical moments, and be patient in passive situations.

Studies have shown that athletes who have undergone systematic psychological training show more adequate psychological reserve in the pre-competition preparation stage, are able to respond to emergencies more calmly during the competition, and maintain higher technical stability in the later stages of the competition. In addition, the effect of mental training will also extend to daily training, so that athletes can maintain higher engagement and continuity in boring basic training.

In the long run, mental training not only helps athletes achieve better competition results, but more importantly, it can cultivate their tenacity and mental qualities, which are of long-term significance to their sports career and life development. Therefore, psychological training should become an indispensable part of the tennis training system, and is as important as technical training and physical training.

5.Challenges of Psychological Training in Tennis Teaching

5.1 Difficulties in the implementation of psychological training in tennis teaching

In the process of integrating psychological training into the practice of tennis teaching, it mainly faces the following challenges:

The reserve of professional teachers is insufficient. As a training content that has only been widely valued in recent years, many tennis teachers have not received systematic and professional psychological education. This leads to a lack of clear direction in the implementation of psychological training, and it is difficult to grasp the key points of training, which in turn affects the actual effect of psychological intervention and ultimately restricts the improvement of athletes’ competitive level. Therefore, it is particularly important to strengthen the psychological training of tennis teachers. However, due to limited educational resources, it is often difficult for schools to organize special training for teachers, which requires teachers to take the initiative to learn relevant theories and independently improve their psychological training literacy.

Class schedules are tight. Tennis courses usually focus on technical training and physical development, and the teaching tasks are heavy. In this case, it is difficult for teachers to provide timely and sufficient psychological attention to each

student. Different students may face different psychological problems, such as competition anxiety, lack of self-confidence or distraction, etc., which can affect the performance of skills at best, and may lead to aggravated psychological disorders and even more serious negative behaviors if not guided in time. Therefore, how to effectively identify and respond to students' psychological needs in limited classroom time has become a major difficulty in integrating psychological training into teaching.

It is difficult to integrate training forms. Psychological training mostly focuses on internal cognition and emotional regulation, the process is relatively static, and the form is relatively simple. Tennis training, on the other hand, is based on dynamic physical exercises, which are varied and interesting. How to naturally integrate static and introspective psychological training into vivid and explicit tennis practice and avoid rigid grafting is an important issue faced by teachers when designing courses. Successful integration requires teachers to have innovative awareness and instructional design ability, so that psychological training and skill training complement each other rather than separate each other^[16].

5.2 Development prospects of psychological training in future tennis teaching

The status of psychological training in tennis teaching will be increasing day by day, and its development may show the following trends:

Psychological training will gradually become a standard part of tennis teaching. With the popularization of sports psychology and the increase in competition pressure, more and more coaches and teachers will recognize the key impact of mental quality on the overall performance of athletes. Systematic mental training not only helps optimize game performance, but also has a long-term maintenance effect on athletes' mental health. Therefore, in the future tennis teaching system, psychological training is no longer an auxiliary means, but a core content that pays equal attention to technique, tactics and physical fitness. Personalized psychological training programs will be more valued. With the diversification and development of athlete groups, the needs of athletes of different genders, ages, levels and personality characteristics for psychological training are also showing a differentiated trend. In the future, tennis teachers should pay more attention to teaching students according to their aptitude and formulate targeted psychological training plans to meet the specific needs of individuals, so as to truly give full play to the effectiveness of psychological training.

The content of psychological training will be more comprehensive and systematic. In the future, tennis teaching will pay more attention to the cultivation of athletes' self-awareness and the improvement of emotional regulation ability, which are the basis for athletes to stay calm and overcome difficulties in high-pressure competitions. In addition, psychological training will more closely combine technical training and physical training courses to form a comprehensive training model of "technical-physical-psychological", so as to comprehensively optimize the performance of athletes.

Finally, athletes' mental health and overall well-being will be important goals of training. Future tennis teachers will not only pay attention to the skill progress of students, but also pay more attention to the improvement of their psychological state and quality of life. By establishing a supportive teaching environment and timely psychological counseling, teachers can help students maintain a positive and healthy mental state while pursuing competitive performance, ultimately achieving all-round growth.

Conclusion

Psychological training plays an important role in youth tennis teaching. Through systematic psychological intervention, athletes can not only make progress at the technical level, but also enhance their self-confidence, concentration and emotional regulation at the psychological level, so as to maintain stable performance in high-pressure competitions. Studies have shown that psychological cues, attention training, appearance training and other methods can significantly improve the success rate of serve and return, and improve athletes' on-the-spot decision-making and adaptability. However, the current implementation of psychological training in tennis teaching still faces challenges such as insufficient professional teachers, limited classroom time, and difficulty in integrating training forms. In the future, we should strengthen the psychological training of teachers, promote the organic integration of psychological training with technical and tactical and physical training, and pay attention to the formulation of personalized psychological plans. Psychological training should become a core component of the tennis teaching system to achieve the coordinated development of athletes' technical ability and psychological quality, and

ultimately promote their all-round growth and the release of long-term competitive potential.

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A Study on the Application of an Innovative Rhythm-Training Approach in Chinese Primary and Secondary School Percussion Education

Yi Huang*

Rua Virgílio Correia, 30 - 2E, 1600-224 Lisboa, Portugal

**Corresponding author: Yi Huang*

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Abstract: This study examines how innovative percussion-teaching approaches—featuring polyrhythm structures and contemporary percussion practices—can be meaningfully integrated into primary and secondary school music education in China. The aim is to support students in developing musical creativity and expanding the expressive scope of their musical language. Guided by concepts of musical creativity, normative musical development, and participatory music practices, this research critically reviews existing scholarship and proposes a new framework for fostering creativity through percussion learning. By drawing together diverse theoretical perspectives and addressing challenges specific to the Chinese educational context, the study articulates an approach to rhythm instruction that balances technical skill with creative exploration. The framework emphasizes the importance of historical context, systematic rhythm training, and collaborative performance experiences in cultivating students' creative capacities and fluency in musical expression. Ultimately, this study seeks to bridge traditional and innovative pedagogies, offering practical strategies for nurturing a new generation of creative young musicians who can communicate effectively through a rich and expressive musical language, contributing to the ongoing development of music education in China.

Keywords: Rhythm; Percussion Education; Innovative Pedagogy; Chinese Music Education; Participatory Music Practice; Musical Language

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1.Introduction

1.1 Research Background and Importance

In recent years, the importance of creativity in music education has been increasingly acknowledged. With ongoing social change and the growing diversity of musical cultures, there is a pressing need to adopt transformative approaches that position creativity as a central dimension of music learning. Creativity is widely regarded as a crucial force that supports students' artistic, cognitive, social, and emotional growth. Incorporating creative approaches into music instruction can spark imagination and innovation, expand students' musical experiences, foster comprehensive musical literacy, and strengthen their fluency in musical language.

However, foundational music education in China has long centered on developing musical literacy and technical skills, with particular emphasis on mastering repertoire. While this model has effectively cultivated discipline and technical proficiency,

it has often left limited space for creative experimentation and personal expression—elements essential for shaping a unique musical identity and for achieving fluency in musical language. In recent years, as music education has expanded significantly in Chinese schools, the need for innovative pedagogies that nurture both performance skills and creativity has become increasingly apparent.

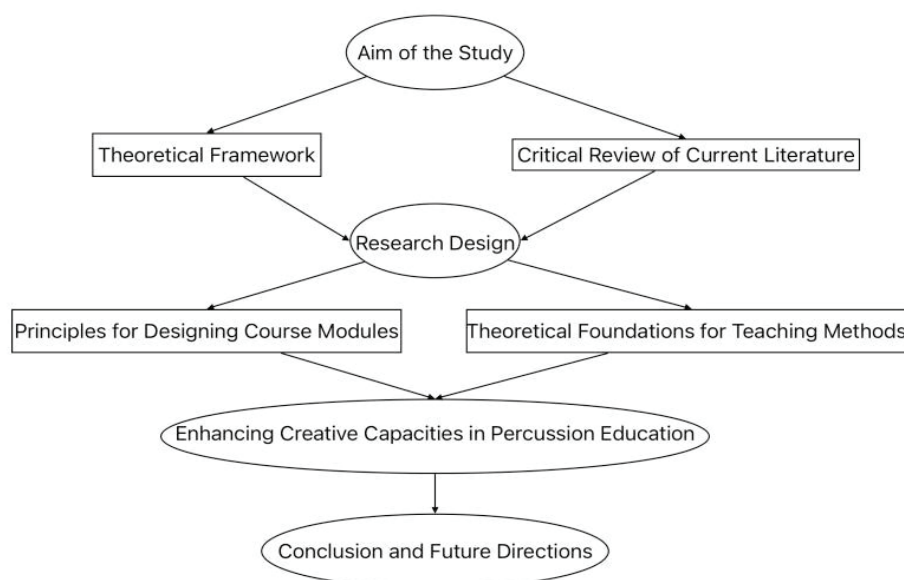
One persistent issue in many Chinese schools is the limited attention given to rhythm education. Despite the centrality of rhythm to musical theory, practice, and musical language, specialized rhythm training is entirely absent in some institutions. Through critical analysis of existing literature, this study addresses this gap by developing a framework that integrates creativity-enhancing, innovative approaches into primary and secondary school percussion curricula. By bringing together contemporary music history, percussion performance techniques, and systematic rhythm training, the study introduces a new pedagogical model aimed at strengthening students' fluency in the rhythmic dimensions of musical language.

The proposed framework seeks to enrich the quality of music education through diversified instructional methods, foster creativity, enhance students' rhythmic awareness, and support their broader musical growth and expressive capabilities. Drawing on established theories and practices while responding to the unique challenges and opportunities of the Chinese educational context, the study synthesizes insights from multiple perspectives and provides practical strategies for implementation. Through these efforts, it aims to offer viable approaches for advancing the development of music education in China.

1.2 Research Objectives

Building on the gaps identified in current practice and the pressing need for innovative approaches in Chinese primary and secondary school percussion education, this study sets out the following objectives. The aim of this research is to develop a theoretically grounded framework that integrates innovative pedagogical strategies to cultivate both creative expression and fluency in musical language within the context of Chinese primary and secondary school percussion education. Specific objectives include:

Figure1: Research Framework



- 1.To critically examine theories of musical creativity, normative musical development, and participatory music practices, synthesizing key insights to establish a robust foundation for the proposed framework.
- 2.To design a suite of teaching strategies grounded in polyrhythm, body percussion, and collaborative learning, aimed at enhancing students' musical expressiveness, teamwork skills, and command of musical language, while addressing specific contextual challenges within the Chinese educational system.
- 3.To introduce adaptable, interactive, and participatory curricular content that opens new possibilities for music education, balancing technical proficiency with creative exploration and respecting established Chinese educational traditions.

4.To propose a comprehensive curriculum design that weaves together historical context, systematic rhythm training, and innovative performance experiences, offering an integrated method for fostering students' musical creativity and linguistic fluency.

5.To provide practical strategies for implementing the proposed framework, including iterative refinement through pilot studies and broader scaling, ensuring adaptability and effectiveness across diverse, real-world teaching environments.

The research structure, illustrated in the accompanying mind map (Figure 1), highlights the key components and their logical progression. By systematically addressing these objectives, this study aims to contribute to the advancement of music education in China, providing a clear roadmap for developing creativity and proficiency in musical language through percussion pedagogy.

2.Theoretical Foundation and Literature Review

This study is grounded in three interrelated theoretical perspectives: theories of musical creativity, normative musical development, and participatory music practices. Together, these perspectives provide a robust, multidimensional framework for exploring the potential of polyrhythm learning and percussion education to cultivate students' creativity.

2.1 Theories of Musical Creativity in Music Education

Theories of musical creativity highlight the central importance of fostering creativity within music education. Creativity is increasingly recognized not as an ancillary goal, but as a core pillar of pedagogy. This perspective is particularly relevant to polyrhythm learning, as mastering complex rhythmic structures demands high levels of creative engagement and problem-solving from students. Webster notes that music education is entering a new era in which creativity is positioned as a central dimension[1]. Humphreys emphasizes that creativity in music education should extend beyond professional composition, formal curricula, or traditional art music, encompassing broader forms of musical practice^[2]. These insights collectively underscore the pervasive and multifaceted role of creativity in music education.

2.2 Normative Musical Development Theory

Normative musical development theory offers a structured, stepwise approach to music education, emphasizing progression from foundational skills to advanced creative expression. Jaques-Dalcroze highlights rhythm training as fundamental to musical development, advocating the use of bodily movement to internalize complex rhythmic structures^[3]. This embodied approach systematically builds students' musical understanding. Further studies by Juntunen and Hyvönen illustrate the application of Dalcroze Eurhythmics, showing that it not only improves rhythmic accuracy but also fosters coordination, creativity, and emotional engagement in music^[4]. Rohrmeier introduces a contemporary perspective by modeling the abstract syntax of musical rhythm, demonstrating the significance of temporal structure in music understanding and providing a scientific framework for rhythm interpretation and reasoning^[5]. These approaches support progressive teaching, enabling students to transition from simple rhythms to the mastery of complex polyrhythms. This perspective aligns with Honing's findings. He further highlighted the interplay between innate rhythmic abilities and learned skills, suggesting that progressive training can enhance both natural aptitude and technical proficiency^[6].

2.3 Participatory Music Practices

Participatory music practice theory emphasizes the social and collaborative dimensions of music education, aligning closely with the collective nature of polyrhythm performance. Small frames music education as a social activity, highlighting that teaching should foster interaction and cooperation among learners, not only individual technical development^[7]. Qiu and Hirunrux examine body percussion education in Guangzhou, demonstrating its benefits for enhancing student collaboration, coordination, and group cohesion^[8]. Interdisciplinary approaches further exemplify participatory practice. Hughes describes a collaborative project at the Edinburgh International Science Festival that combined new music percussion with scientific exploration to create an immersive, multisensory experience^[9]. This project bridged tradition and innovation, showing how interdisciplinary education can engage diverse audiences while nurturing creativity.

2.4 Integrating the Three Perspectives

The relationships among normative musical development theory, musical creativity theories, and participatory music practices can be understood as mutually supportive and complementary, forming a unified theoretical framework for music education

(Figure 2). This integrated framework aims to cultivate both students' musical creativity and their holistic development.

Based on this framework, the following hypotheses illustrate the interplay among the perspectives:

H1: Normative musical development as a foundation for musical creativity

Normative musical development provides the necessary skills and knowledge for creative musical practice. Polyrhythm learning and interdisciplinary collaboration further reinforce musical creativity.

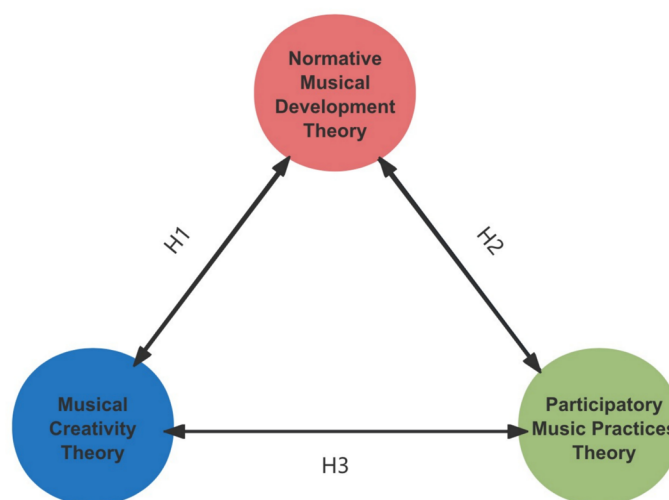
H2: Reciprocal influence between musical development and participatory practice

Music development and participatory practice influence each other bidirectionally. Improvements in educational policies and strategies enhance participatory practices, which in turn inform and refine music development.

H3: Participatory music practices as a bridging mechanism

Participatory practices bridge musical creativity and normative musical development, emphasizing experiential learning and collaboration. Activities such as improvisation and ensemble performance cultivate creativity, refine students' ideas, and enhance interpersonal skills.

Figure2: Theoretical Framework Flowchart



3. Critical Review of Rhythm Education Research and Challenges

3.1 Challenges and Insights in Fostering Creativity in Music Education

Csikszentmihalyi argue that effective music educators should simultaneously cultivate two forms of creative musical expression: reproducing existing music and engaging in improvisation^[10]. Both activities mutually reinforce one another and are essential for comprehensive musical development. However, educators often struggle to integrate creativity into their teaching. Dogani notes that teachers frequently focus on a single dimension of music education, overlooking multidimensional development^[11]. Economidou Stavrou emphasized that inadequate teacher training in creative processes is a significant barrier, and further highlighted the potential for creative music projects to influence teacher beliefs, suggesting that these insights should be incorporated into teacher training^[12]. Henry identifies limited instructional time as another constraint, with educators often prioritizing skill acquisition over creative activities^[13]. These challenges highlight the need for innovative approaches, such as polyrhythm learning, to balance technical skill development with creativity cultivation.

In the context of Chinese education, rhythm instruction is shaped by a range of structural and pedagogical dynamics. Yu and Leung examined the implementation of the new Music Curriculum Standards in China, noting that while these standards emphasize creativity and student-centered learning, many teachers struggle to translate these principles into practice due to a lack of training and resources^[14]. Zhou further investigated the impact of teaching methods on creativity, surveying 224 students across four music secondary schools in Tianjin^[15]. Her findings indicate that instructional strategies significantly influence students' creative output, particularly in composing original melodies integrating diverse rhythms, harmonies, and tonalities, though she acknowledges the difficulty of defining and systematically assessing creativity in this educational context. These insights underscore the complexity of rhythm education in China and the importance of context-sensitive curricula and pedagogical strategies. They also highlight the need for scalable, reliable tools to evaluate creativity in music

education, laying the groundwork for future improvements in teaching practice.

3.2 The Role of Social Interaction and Creative Music Curricula

Jaques-Dalcroze advocated for creative, active learning strategies in music education to encourage deeper engagement. Techniques such as polyrhythm training, body percussion, and improvisation allow students to experiment with novel rhythmic combinations, develop problem-solving skills, and foster active participation. Music education should extend beyond technical skill acquisition, emphasizing creativity and personal expression. Research by Hargreaves et al. highlights the importance of social interaction and collaboration in music education^[16]. Small introduced the concept of musicking, framing music as a dynamic social activity in which all participants—performers, listeners, and composers—play a vital role. This collaborative process fosters a sense of shared belonging and encourages creative expression.

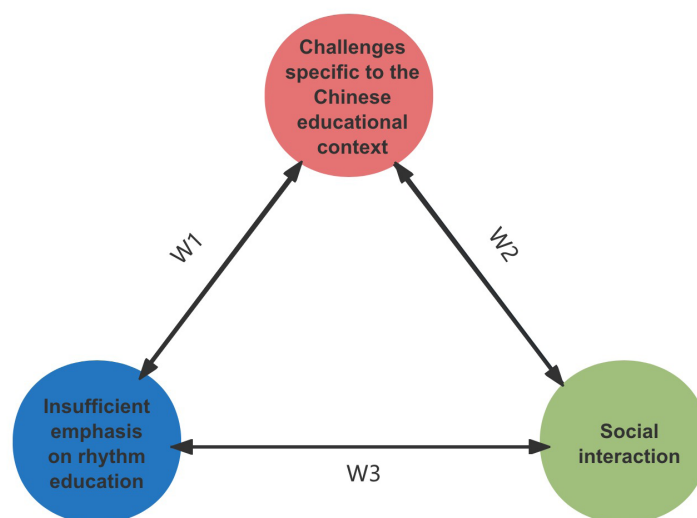
3.3 Insufficient Emphasis on Rhythm Education

Rhythm is foundational to musical experience across all cultures, yet it remains underexplored in many educational systems. In Chinese primary and secondary school rhythm education plays a key role in developing musical literacy but is not always sufficiently emphasized. Some studies report that music lessons resemble other cultural subjects, focusing on theoretical knowledge and rote memorization. Such traditional methods may limit student engagement and fail to address the practical and enjoyable aspects of music education. In some schools, music instruction focuses primarily on singing, with less attention to rhythm and other musical skills. Teachers may not fully recognize the importance of rhythm training, and pedagogical approaches may not align with contemporary educational needs. Given that rhythm forms the basis of music, it is closely linked to students' musical perception, creativity, and aesthetic appreciation. Integrating techniques such as body movement and instrumental practice can enhance rhythmic sense and improve overall quality of music education. Rhythm is not only essential for performance but also for developing musical imagination and expressive abilities.

3.4 Multidimensional Framework and Interrelated Challenges

Figure 3 presents the three key challenges affecting the development and implementation of rhythm education in the Chinese context, along with their interrelationships:

Figure3: Multidimensional Methodological Framework Flowchart



W1: Impact of Contextual Challenges on Rhythm Education

Specific challenges in the Chinese education system—such as disparities in resource availability, exam-oriented priorities, and differences in teacher training—directly influence the emphasis placed on rhythm instruction. The arrow labeled “W1” indicates that systemic issues may inadvertently deprioritize rhythm education. In environments dominated by limited resources and adherence to established norms, introducing rhythm-centered approaches may face significant practical constraints.

W2: Reciprocal Influence Between Contextual Challenges and Social Interaction

The bidirectional arrow “W2” represents the interaction between systemic challenges and opportunities for social interaction

in music education. Constraints such as exam-focused goals and limited resources may restrict the feasibility of implementing interactive, student-centered learning. Conversely, a lack of social interaction may reinforce the individualistic, test-driven nature of the educational environment, perpetuating these challenges and making it more difficult to prioritize collaborative learning experiences.

W3: Effect of Insufficient Rhythm Education on Social Interaction

The arrow labeled “W3” emphasizes that insufficient attention to rhythm education can reduce opportunities for social interaction in music learning. Rhythm is fundamental for group cohesion and collective musical creation. When rhythm instruction is underrepresented, students may lack opportunities to participate in collaborative musical experiences that foster social connections, teamwork, and interpersonal skills. Greater emphasis on rhythm education can strengthen these social dynamics, allowing students to engage more fully in shared musical activities while simultaneously developing essential social competencies.

4. Pedagogical Framework and Course Design

This curriculum is designed following a comprehensive and systematic approach, organized into three core modules:

4.1 Historical Context: Development of Contemporary Music

This foundational module provides students with a broad overview of contemporary music from the 1920s to the present, covering both Western and Chinese developments.

Western Contemporary Music: Students explore pioneering works by composers such as Arnold Schoenberg, Olivier Messiaen, and Alban Berg. Detailed study includes Schoenberg’s twelve-tone system, Messiaen’s distinctive harmonic language and rhythmic complexity, and Berg’s expressive atonal works. Engaging video demonstrations, carefully selected musical examples, and interactive classroom discussions help students understand how these composers challenged traditional conventions and paved the way for new forms of musical expression.

Chinese Contemporary Music: Focus shifts to notable Chinese composers, including Tan Dun, Chen Qigang, and Guo Wenjing. Students examine how these composers successfully blend Western compositional techniques with traditional Chinese musical elements, creating distinctive and internationally recognized Chinese contemporary music. Innovations such as Tan Dun’s use of unconventional instruments and multimedia, Chen Qigang’s integration of folk melodies with Western orchestration, and Guo Wenjing’s powerful, emotionally charged works serve as exemplars of cultural synthesis.

Throughout the module, the central role of rhythm in contemporary music is emphasized. Students observe how composers experiment with complex rhythmic structures, polyrhythms, and irregular meters to create novel and engaging musical textures. This historical foundation prepares students for practical applications, allowing them to explore creative possibilities of rhythm in their own musical attempts.

4.2 Rhythm Training: Polyrhythms and Body Percussion Techniques

This module focuses on mastering complex polyrhythms (e.g., 3:4, 3:5) and body percussion exercises. Carefully designed activities guide students from fundamental patterns to more advanced forms. Under guided instruction, students use body percussion and ensemble exercises to deconstruct and internalize complex rhythms. For example, students practice creating layered rhythmic textures in groups, fostering individual precision and ensemble cohesion. The Takadimi system and some polyrhythmic training exercises are incorporated to enhance personal skill development and group collaboration^[17]. Digital tools, such as Composite Tool, are used to visualize and analyze complex rhythms, bridging theoretical concepts and practical application^[18]. This approach facilitates deeper understanding and mastery of intricate rhythmic structures. Consistent with Jaques-Dalcroze, active, creative learning through body percussion and improvisation enhances problem-solving skills, engagement, and participatory learning, encouraging students to develop both musical skills and creative thinking.

4.3 Percussion Performance: Innovation and Collaborative Application

This module provides students with opportunities to apply their skills in rehearsal and performance of two to three contemporary percussion ensemble pieces. Selected repertoire balances technical challenge with musical expressivity, ensuring all students can contribute meaningfully regardless of skill level. Students are encouraged to select or compose their own works, promoting creativity, autonomy, and ownership of learning. Brainstorming sessions allow experimentation

with sound and collaborative creation of original compositions. Teamwork and achieving musical balance are emphasized, incorporating unconventional instruments such as everyday objects or body percussion. These innovative methods encourage students to explore the full potential of sound in creative music-making. Through music, adolescents can develop self-identity while enhancing social skills through interaction and comparison with peers.

5.Application of Polyrhythm Theory and Innovative Pedagogical Approaches

This section details the practical implementation of polyrhythm theory in the curriculum, highlighting the integration of innovative teaching methods, technological tools, and iterative course refinement.

5.1 Application of Polyrhythm Theory

The curriculum effectively utilizes the Takadimi system (Figure 6) and polyrhythm exercises (Figure 4 and Figure 5) to guide students from deconstructing complex rhythms to understanding their integrated structures.

Figure4: Højsgaard, Erik. 2016. *Rhythm: Advanced Studies*, p.52.



Figure 5: Cangelosi, Casey. 2017. *Shape Class*, p.136.

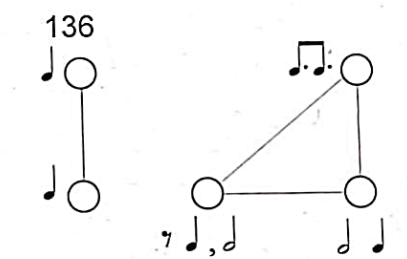


Figure 6: Hoffman, Richard. 2009. *Learning Rhythm with the Takadimi Sight-Singing System*.



Irregular divisions — To perform irregular divisions of the beat, add a syllable to a common pattern.



Asymmetric meters — Asymmetric meters combine simple and compound divisions. Keeping the divisions equal will produce beats of varied lengths.



By breaking down complex polyrhythms into simpler components, students gain a deeper understanding of intrinsic rhythmic relationships. The Takadimi system employs intuitive syllabic representations of rhythm, enabling students to internalize and verbalize intricate rhythmic patterns. This approach not only enhances their ability to perform polyrhythms accurately but

also fosters a more comprehensive grasp of rhythm as a conceptual and practical element of music.

Additionally, the integration of body percussion and layered rhythmic techniques has proven critical in developing students' understanding of rhythmic dynamics. Experiencing different rhythmic layers physically allows students to perceive interactions among rhythmic elements. Kinesthetic engagement helps students feel the pulse, subdivisions, and syncopations inherent in polyrhythmic structures. Moreover, collaborative exercises further teach students to align their rhythms with those of their peers, enhancing ensemble awareness and precision.

5.2 Integration of Innovative Teaching Methods

The curriculum successfully incorporates learner-centered approaches, prioritizing active participation and collaborative music-making. Moving beyond traditional teacher-centered instruction, students are empowered to take ownership of their learning. Techniques such as role rotation and group collaboration cultivate leadership skills, effective communication, and a strong sense of shared responsibility for musical outcomes. Democratizing classroom dynamics creates a safe and inclusive space, encouraging students to experiment, take risks, and contribute unique perspectives. This supportive environment is essential for fostering creativity and self-expression. Through open-ended discussions, brainstorming sessions, and improvisation exercises, students develop critical thinking, inquiry skills, and the ability to explore unconventional ideas. These experiences deepen their understanding of rhythmic concepts while nurturing a lifelong engagement with music and learning.

Moreover, the integration of digital tools, such as the Composite Tool, further enhances the learning experience by providing visual representations of complex rhythmic structures. Interactive resources allow students to manipulate and analyze rhythms in real-time, promoting intuitive understanding of polyrhythmic relationships. By leveraging technology, the curriculum bridges the gap between theoretical concepts and practical application, equipping students with skills necessary to navigate an increasingly digital musical environment.

5.3 Cultivating Creative Thinking and Growth Mindset

The curriculum emphasizes strategies that encourage a growth mindset in approaching rhythm education. Students learn to view challenges as opportunities for learning and development, building resilience and perseverance when tackling complex rhythmic tasks. Mistakes are framed as valuable feedback, and iterative trial-and-error processes support refinement of ideas. This mindset fosters a culture of continuous improvement and self-reflection, qualities essential for long-term success in music and other disciplines.

5.4 Iterative Refinement Through Practice and Feedback

The curriculum employs an iterative design approach, ensuring responsiveness to the evolving needs of students and educators. Pilot studies and stakeholder feedback guide ongoing refinement, allowing adjustments that enhance effectiveness and adaptability across diverse learning environments. Active participation of teachers and coordinators in these trials is crucial for identifying strengths and areas for improvement. Documenting their experiences, challenges, and successes contributes to a rich feedback loop, informing future iterations of the curriculum and ensuring alignment with classroom realities. Student feedback is equally vital. By actively soliciting and incorporating student perspectives, the curriculum better addresses their interests, learning styles, and aspirations. Regular assessment of learning outcomes provides tangible evidence of the curriculum's impact, supporting data-driven decisions in its ongoing development. This evidence-based approach ensures the curriculum remains effective in achieving its intended objectives and fostering student creativity.

6. Conclusion

This study aims to provide a practical framework for integrating innovative percussion pedagogy into primary and secondary music education in China, with a focus on fostering creativity and developing rhythmic skills. By drawing on multiple theoretical perspectives, the framework seeks to offer a structured yet flexible approach that combines historical context, systematic rhythm training, and collaborative performance experiences. The curriculum design emphasizes learner-centered and participatory approaches, encouraging students to actively engage in music-making, experiment with rhythms, and develop their own expressive voices. While the framework is still exploratory, its iterative nature allows for ongoing adaptation based on student and educator feedback, helping to identify practical strategies that may support creativity and

musical development in diverse classroom contexts. Rather than presenting a definitive solution, the framework offers a starting point for educators and researchers to explore, refine, and expand methods that balance technical skill development with creative exploration. Ultimately, this study hopes to contribute to ongoing conversations about music education in China, providing insights and strategies that may inform future practice, curriculum design, and research, while acknowledging that much work remains to be done to fully realize the potential of innovative, creativity-oriented percussion education.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research on the Pathway of AI Technology Empowering the Development of Core Competencies in Middle School Mathematics

Zhengying Fan*

Jiefang High School, Wuhan, Hubei, 430000, China

**Corresponding author: Zhengying Fan*

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Abstract: In the context of digital transformation, AI technology, with its core advantages in data processing, intelligent interaction, and personalized adaptation, provides new momentum for the reform of middle school mathematics education. The core competencies in middle school mathematics, as a concentrated reflection of students' mathematical abilities and thinking qualities, face practical challenges in their cultivation process, such as insufficient personalized guidance and difficulties in visualizing thinking. Based on the characteristics of AI technology applications in education, and combined with the connotative requirements of core competencies in middle school mathematics, this research systematically explores the empowering pathways of AI technology from the six dimensions of core competencies: mathematical abstraction, logical reasoning, mathematical modeling, intuitive imagination, mathematical operation, and data analysis. It also analyzes problems encountered during application and proposes optimization strategies, providing theoretical reference for promoting the deep integration of AI and middle school mathematics education and enhancing the effectiveness of core competency cultivation.

Keywords: AI Technology; Middle School Mathematics; Core Competencies; Empowering Pathway; Educational Integration

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1.Introduction

With the rapid development of new-generation information technologies represented by artificial intelligence, big data, and cloud computing, all sectors of society are undergoing profound digital transformation. Education, as a key foundation for social development, has also encountered a historical opportunity for systemic change. Artificial intelligence technology has accelerated its penetration from early theoretical exploration and laboratory settings into the front lines of teaching and learning, gradually becoming a key supporting force in promoting educational modernization and building a high-quality education system. In this process, how to effectively utilize AI technology to solve traditional educational challenges and promote holistic human development has become a core issue of common concern for educational researchers and practitioners.

Mathematics, as a key subject in the basic education stage for cultivating students' rational thinking, scientific spirit, and problem-solving abilities, has seen its educational objectives shift from traditional knowledge transmission and skill training to a comprehensive cultivation guided by core competencies. Both The Mathematics Curriculum Standards for Compulsory

Education (2022 Edition) and The General High School Mathematics Curriculum Standards (2017 Edition, 2020 Revision) clearly state that mathematics education should aim to develop students' core mathematical competencies, enabling them to form the mathematical thinking abilities, practical skills, and emotional attitudes/values necessary for lifelong learning and societal development. Core competencies in middle school mathematics are not isolated knowledge points or skills but an organic integration of mathematical knowledge, key abilities, thinking methods, and value concepts. They are comprehensive qualities with distinct mathematical disciplinary characteristics that students gradually develop through mathematics learning. Their formation is a long-term, gradual, and implicit process, relying on the careful creation of teaching contexts, deep engagement in the learning process, and the continuous guidance of evaluation feedback, posing new challenges to traditional teaching models.

For a long time, under the teaching mode dominated by the class-based instruction system, teachers have been constrained by factors such as large student numbers, significant individual differences, and limited teaching time. In cultivating core competencies like mathematical abstraction and logical reasoning, they have mostly had to adopt methods like uniform explanation and example demonstration, finding it difficult to accurately grasp each student's thinking bottlenecks and cognitive obstacles, and lacking the capacity to provide differentiated training and feedback. This has led to situations where students' abstract thinking easily falls into the dilemma of "understanding when explained but not being able to conceive independently," logical reasoning lacks verification opportunities, and modeling and data analysis become merely formalistic. The contradiction between "broad-spectrum" teaching and "precise" competency cultivation has become a major bottleneck in improving the quality of middle school mathematics education. The rise of AI technology provides instrumental support for solving this dilemma. It can achieve precise learning diagnosis through the collection and analysis of vast amounts of educational data, realize intelligent interaction and adaptive feedback through algorithms like natural language processing, and enable visualization of thinking through technologies like virtual simulation. These characteristics make it a new type of teaching tool that can deeply align with the personalized pathways and visual scaffolds required for core competency cultivation, becoming a key enabler for achieving scaled personalized education.

Systematic research on the internal logic and practical pathways of how AI technology can assist in the development of core competencies in middle school mathematics holds significant theoretical importance and practical urgency. It is a necessary requirement for conforming to the strategic action of educational digitization and promoting the deep integration of technology and education, as well as a key focal point for deepening mathematics curriculum reform and effectively implementing the goals of core competency cultivation into every aspect of classroom teaching. This study aims to deeply analyze the characteristics of AI technology applications in education and the connotative requirements of core competencies in middle school mathematics, explore effective connection points and empowerment mechanisms between the two, and provide reference for constructing a new paradigm of middle school mathematics teaching in the context of the intelligent era.

2. Definition of Core Concepts

2.1 Core Competencies in Middle School Mathematics

Mathematical core competencies are the infiltration and fusion of general core competencies within a specific subject, guiding the curriculum and teaching across different learning stages. Their formation and development primarily use mathematical knowledge as the carrier and mathematical activities as the main pathway^[1]. Core competencies in middle school mathematics are the thinking qualities and key abilities with distinct mathematical disciplinary characteristics that students gradually internalize through understanding, applying, and analyzing mathematical knowledge during their mathematics learning process in middle and high school. They are a concentrated manifestation of the educational value of mathematics education under the fundamental task of "fostering virtue through education" and constitute a crucial mathematical foundation for students to adapt to lifelong learning and meet future societal challenges. According to the clear definitions in The Mathematics Curriculum Standards for Compulsory Education (2022 Edition) and The General High School Mathematics Curriculum Standards (2017 Edition, 2020 Revision), core competencies in middle school mathematics comprise six interconnected and organically integrated dimensions. Each dimension plays a different role in the development of students' mathematical abilities, together constructing the core objective system of middle school mathematics education:

Mathematical abstraction refers to the ability to extract the essential mathematical attributes from concrete situations or objects; Logical reasoning is the ability to engage in rigorous thinking based on existing facts and rules to derive reasonable conclusions; Mathematical modeling is the ability to transform practical problems into mathematical problems and solve them; Intuitive imagination is the ability to perceive mathematical relationships and construct mathematical imagery through graphics; Mathematical operation is the ability to perform accurate calculations and reasoning according to mathematical rules; Data analysis is the ability to collect, organize, analyze data, and extract useful information. These six competencies are interrelated and unified, collectively forming the core objectives of middle school mathematics education.

2.2 AI Technology in the Educational Field

AI technology in the educational field refers to intelligent systems, tools, and platforms developed based on core AI technologies such as machine learning, natural language processing, computer vision, virtual reality, and augmented reality, combined with the specific needs of teaching and learning, to optimize the teaching process and enhance learning effectiveness^[2]. Its core purpose is to use technology to solve problems in traditional education such as insufficient personalization, delayed feedback, and uneven resource distribution, providing precise and intelligent support for core competency cultivation. Compared to traditional educational technologies like multimedia courseware and projectors, it places greater emphasis on “intelligence” and “adaptability.” It can adjust service content in real-time based on dynamic data from the teaching process, such as student learning behaviors and answer patterns, achieving “teaching determined by learning.” The core functions of AI technology in education can be detailed into five modules, each with clear application scenarios in middle school mathematics teaching, directly serving core competency cultivation: Intelligent diagnosis identifies knowledge weaknesses by analyzing student learning behavior data; Personalized recommendation pushes adapted learning resources based on student learning characteristics; Interactive feedback enables immediate teaching interaction through intelligent Q&A and real-time comments; Visualization of thinking presents abstract mathematical relationships through graphical and dynamic means; Automated processing handles repetitive teaching tasks like homework grading and learning analysis. Compared to traditional educational technology, AI technology emphasizes “intelligence” and “adaptability” more, adjusting service content according to dynamic changes in the teaching process to provide precise support for core competency cultivation.

3. Specific Pathways for AI Technology to Empower the Development of Core Competencies in Middle School Mathematics

3.1 Assisting the Cultivation of Abstraction and Intuitive Imagination Competencies through Thinking Construction

Mathematical abstraction and intuitive imagination, as the foundational and extended components of mathematical thinking, together constitute key abilities for students to move from concrete perception to grasping essence, and from static understanding to dynamic construction. AI technology, with its support for visualization, dynamization, and interactivity, effectively promotes the synergistic development of these two competencies.

In the field of mathematical abstraction, AI can use technologies like virtual reality (VR) and augmented reality (AR) to transform abstract concepts into experiential concrete situations, guiding students to extract essential mathematical attributes through comparisons in various contexts. The system uses intelligent questioning, variant training, and immediate feedback to help students gradually build cognitive steps from the concrete to the abstract, strengthening their understanding of the connotation and extension of concepts. In terms of intuitive imagination, AI tools like dynamic geometry sketchpads and 3D modeling systems support real-time transformation, rotation, and scaling of graphics, allowing students to intuitively analyze geometric relationships and spatial structures. During function learning, AI achieves real-time linkage between numbers and shapes, visually presenting image changes through parameter adjustments, deepening students’ understanding of function properties and their correlation with graphs. Combined, AI not only reduces the entry difficulty of abstract thinking but also expands the dimensions of spatial imagination construction, promoting the formation of students’ complete mathematical representation and imaginative abilities.

3.2 Solidifying Logical Reasoning and Mathematical Operation Competencies through Process Rigor

Logical reasoning and mathematical operation together reflect the rigor and procedural nature of mathematical thinking, with logical reasoning focusing more on the rationality of the thinking process, and mathematical operation emphasizing the accuracy and optimization of the operational process. AI technology provides structured and precise support for these two competencies through functions like process visualization, rule guidance, and error diagnosis.

In cultivating logical reasoning, AI systems can record students' reasoning steps, perform real-time judgment based on logical rules, and provide feedback. In the stage of plausible reasoning, the system can present patterned materials to guide students in making conjectures and use probing questions to prompt reflection; during deductive reasoning training, AI tools support step-by-step input and logical verification, can locate flaws in reasoning and push related rule explanations, helping students construct rigorous reasoning chains. In mathematical operation, AI pays attention not only to the correctness of results but also to the analysis of calculation strategies and process optimization. Intelligent diagnostic systems can identify error types, such as rule-based errors or strategic mistakes, and push targeted training. For complex calculations, AI guides students to conduct strategy analysis first and then use tools to complete the computation, achieving a shift from mechanical execution to intelligent operation. Through the combination of both, AI helps students improve both rigor and efficiency at the levels of thinking and operation.

3.3 Enhancing Mathematical Modeling and Data Analysis Competencies through Practical Application

Mathematical modeling and data analysis competencies highlight the connection between mathematics and the real world, emphasizing extracting information from practical problems, constructing models, and making reasonable judgments. AI technology provides students with a close-to-reality and fully supported learning experience through functions like context creation, process scaffolding, and result simulation.

In mathematical modeling, AI can integrate practical problems from various fields based on big data and adapt and simplify contexts according to students' cognitive levels ^[3]. The system provides guidance for problem decomposition, a mathematical tool library, and method indexing during the modeling process to support students throughout the entire process from problem identification to model construction. Teachers can also use 3D modeling software (e.g., AutoCAD) to construct models of real-world engineering problems related to the curriculum ^[4]. In data analysis, AI systems can simulate the data collection process, provide efficient data organization and visualization tools, and help students focus on key information through chart interaction. The system guides data interpretation through questioning, cultivating students' ability to extract information and make inferences from data. Together, these two aspects demonstrate AI's supportive role in connecting mathematics with reality and enhancing students' comprehensive application abilities.

4.Challenges and Countermeasures for AI Technology Empowering the Development of Core Competencies in Middle School Mathematics

4.1 Main Challenges

Educational issues are the "characteristics" of education; whenever new technology enters educational practice, countless new problems arise ^[5]. Although AI technology offers many possibilities for cultivating core competencies in middle school mathematics, it still faces a series of challenges in practical application. There is a prominent tendency towards "instrumentalization" in technology application. In some teaching practices, AI technology merely serves as a substitute for traditional teaching tools, failing to fully integrate into the entire process of core competency cultivation and not fully leveraging its intelligent advantages. Teachers' AI application abilities are insufficient; some teachers lack adequate understanding of the functional characteristics and application scenarios of AI technology and lack the instructional design ability to precisely align AI technology with core competency cultivation goals. Teaching practice reveals that due to insufficient mathematical foundations among students, algorithm improvement is relatively difficult to implement at the high school stage ^[6]. The quality of educational AI resources is uneven; some resources focus only on formal innovation, lacking precise support for core competency cultivation goals and failing to meet teaching needs.

4.2 Optimization Strategies

In response to the aforementioned challenges, optimization strategies should be proposed from four levels: technology

application, teacher development, student cultivation, and resource construction. At the technology application level, it is necessary to establish an “competency-oriented” application philosophy, integrating core competency cultivation goals throughout the entire process of instructional design, implementation, and evaluation of AI technology application, achieving precise alignment between technological functions and competency needs. At the teacher development level, a systematic AI education competency training system should be constructed. Through means such as thematic training, case studies, and practical exercises, teachers’ application abilities and instructional design capabilities regarding AI technology should be enhanced, fostering their awareness of technology integration. At the student cultivation level, artificial intelligence-related courses should be offered in primary and secondary schools ^[7], improving curriculum plans and standards, and enriching the content of artificial intelligence and programming courses to meet the development needs of the information age and intelligent era ^[8]. At the resource construction level, a quality standard system for AI educational resources should be established, high-quality resources should be integrated, and thematic resource libraries focused on core competency cultivation should be developed to provide high-quality resource support for teaching practice.

5. Conclusion and Outlook

AI technology, with its unique functional advantages, offers various empowering pathways for the development of core competencies in middle school mathematics. Through precise application in the six competency dimensions of mathematical abstraction, logical reasoning, mathematical modeling, intuitive imagination, mathematical operation, and data analysis, AI technology can effectively break through the limitations of traditional teaching, promoting the process of core competency cultivation towards personalization, visualization, and precision. However, the application of AI technology in the educational field is not flawless; the realization of its value depends on the innovation of technology application concepts, the improvement of teacher capabilities, the guidance of student usage methods, and the support of high-quality resources.

With the continuous advancement of AI technology and the ongoing renewal of educational concepts, the integration of AI and middle school mathematics education will deepen further. On one hand, AI technology will evolve towards greater intelligence and personalization, capable of more accurately grasping students’ thinking characteristics and learning needs, providing more targeted assistance for core competency cultivation. On the other hand, the integration of AI technology with other educational technologies will become closer, constructing a multi-technology collaborative educational ecosystem, and creating a more comprehensive support system for core competency cultivation. In this process, it is essential to consistently uphold the “education-oriented” educational philosophy, combine technology application with educational principles, fully leverage the auxiliary role of AI technology, continuously improve the quality of core competency cultivation in middle school mathematics, and lay a solid foundation for students’ lifelong development.

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A Study on the Association between Interface Usability and Visit Intention of the Digital Museum of the Forbidden City: Design Analysis Based on Heuristic Evaluation

Qingyi Deng^{1,2*}, Khayril Anwar Bin Khairudin², Gufeng Wu³

1. Guangzhou Huali College, Guangzhou 511325, China

2. Faculty of Art & Design, Universiti Teknologi MARA (UiTM), 32610, Seri Iskandar, Perak, Malaysia

3. Faculty of Education, Puncak Alam Campus, Universiti Teknologi MARA (UiTM), 40450, Selangor, Malaysia

*Corresponding author: Qingyi Deng, dengqingyi0505@163.com

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Abstract: This study, based on the Technology Acceptance Model (TAM) as the explanatory framework, focuses on how the interface usability of the Digital Palace Mini Program (mobile version) affects the intention to access through the user experience mechanism. A purely qualitative design analysis was conducted using heuristic evaluation and task walkthroughs. The study selected five key pages (such as navigation, routes, etc.) and six typical task paths to construct an evidence chain, systematically identifying and summarizing the types of interface issues. The research reveals that usability issues mainly fall into five categories: information architecture and labels, visibility of navigation and paths, search and discoverability, feedback and error tolerance, readability, consistency, and accessibility. These problems tend to be magnified in continuous task chains by increasing cognitive load and uncertainty, weakening control and trust, thereby reducing perceived ease of use (PEOU), and further affecting content acquisition efficiency and perceived usefulness (PU), thus suppressing the tendency for continuous visits and returns. Based on evidence-based discovery, this paper proposes executable optimization suggestions for the interface of digital museums, providing design references for enhancing the accessibility and continuous usage of digital cultural heritage platforms for the public.

Keywords: Digital Palace; Interface Usability; Heuristic Evaluation; Task Walkthrough; Technology Acceptance Model (TAM); Intention to Access

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1. Introduction

1.1 Background and Research Motivation

Digital museums are becoming an important gateway for the public to access cultural heritage. Their value extends beyond the mere digitization of collections; it lies in transforming knowledge, exploration paths, and cultural experiences into understandable and sustainable daily usage scenarios through interfaces and interactions^{[1][2]}. Digital cultural platforms such as the Digital Museum of the Forbidden City typically feature high information density, diverse content types, and frequent cross-level navigation. Users' browsing, searching, understanding, and immersion often require the interface to provide clear structure, stable paths, and timely feedback. For most non-professional users, whether they will continue to engage is

determined not by the content value itself, but is rapidly shaped by the interface experience at several key nodes: being unable to find an entry point, not understanding the classification, receiving unclear feedback, and encountering inefficient search can all cause the exploration to be interrupted at an early stage.

In this context, the issue of usability is not merely an operational flaw; it can alter users' overall judgment of whether the platform is user friendly and worth their investment, and further influence the tendency for continued access and return visits. The Technology Acceptance Model (TAM) provides a straightforward explanation: perceived ease of use and perceived usefulness influence users' behavioral intentions^[3]. Therefore, to understand the issue of continuous visits to the Digital Palace, merely focusing on macro level dissemination or technical presentation is insufficient. Instead, it is necessary to return to the interface level and present a traceable evidence chain that proceeds from specific problems to experience consequences, and then to intention tendencies^{[1][2]}.

Based on this, this study takes the interface of the Digital Museum of the Forbidden City as a case, conducts a systematic usability diagnosis based on actual task processes and, within the explanatory framework of TAM, provides a qualitative interpretation of how usability affects the intention to access, thereby offering a more operational design basis for the interface optimization of digital cultural heritage platforms. Therefore, the motivation of this study is as follows: taking the interface of the Digital Museum of the Forbidden City as a case, from a design perspective, a systematic usability inspection method is adopted to identify key issues. Under the explanatory framework of TAM, the correlations among usability, experience mechanism, and access intention are qualitatively explained, thereby providing an executable design basis for the interface optimization of digital cultural heritage platforms.

1.2 Research Objectives Questions and Contributions

This study aims to identify the key usability issues of the Digital Museum of the Forbidden City interface, explain the mechanism by which these issues affect users' intention to visit, and propose actionable suggestions for interface optimization. The research questions are as follows:

RQ1: What are the key usability issues present in the interface of the Digital Museum of the Forbidden City?

RQ2: How do these usability issues affect users' intention to visit (qualitative mechanism)?

RQ3: Based on the assessment results, what actionable interface optimization suggestions can be proposed?

In terms of methodology, this paper employs heuristic evaluation and task walkthrough to construct the evidence chain: heuristic evaluation is used to systematically identify interface and interaction issues^{[4][5]}, while task walkthrough is used to identify key difficulty points and interruption points along typical task paths and to analyze how they lead to experience consequences such as uncertainty, frustration, or reduced trust^[6]. At the theoretical level, this paper uses the Technology Acceptance Model (TAM) as the explanatory framework to conduct a qualitative interpretation of the relationships among interface issues, perceived ease of use, perceived usefulness, and intention to access^{[3][7]}.

The contribution of this paper lies in its use of a traceable interface evidence chain to reveal the structured types of interface usability problems in digital museums. Within the TAM framework, it further explains how usability problems affect the intention to access through experience consequences and, based on this, refines executable interface optimization suggestions for digital cultural heritage platforms.

2. Literature Review and Conceptual Framework

2.1 Digital Museums Interface Research: Focus and Trends

In response to the research concerns raised in the introduction regarding how the usability of digital museum interfaces affects users' intention to continue visiting and returning, this section outlines the common discussion dimensions and analytical perspectives of related research to provide context for this study and to explain the rationale for the subsequent conceptual framework and method selection. Regarding research on the interfaces of digital museums and digital heritage platforms, discussions have long moved beyond merely digitizing and publishing collections. Instead, they increasingly focus on how users achieve understanding, exploration, and sustained participation through the screen medium. Existing studies generally point out that digital museum interfaces face typical challenges such as high content density, diverse content types, and complex navigation paths: users may engage in browsing-style exploration with low goal specificity or perform searches and

learning with clear objectives. Therefore, interface design needs to balance information organization, interaction guidance, and experience presentation ^{[1][8]}.

At the level of information organization, information architecture and label design have been repeatedly identified as key factors influencing users' comprehension and content orientation. For platforms that operate multiple modules in parallel, such as exhibitions, collections, knowledge interpretation, and educational tours, whether the classification logic aligns with users' mental models, whether terminology is used consistently, and whether the hierarchy is appropriate directly affect users' ability to locate and understand content. Closely related to information organization is research on interaction guidance, which examines whether the navigation structure is stable, whether the current location and return path are clear, whether key entry points are sufficiently visible, and whether system feedback supports users in advancing through task sequences (e.g., searching, filtering, accessing details, and extended reading). When guidance mechanisms are inadequate, users are more likely to experience disorientation and uncertainty, which can lead to premature discontinuation of exploration ^[9].

Meanwhile, immersive experiences and narrative presentations (such as 3D displays, AR/VR, and interactive narratives) have become an important development direction for digital museums in recent years. Most related studies suggest that these presentation methods can enhance the sense of presence and emotional engagement, thereby increasing cultural participation and learning motivation. However, some research also points out that immersive technologies may introduce learning costs, operational complexity, and equipment barriers. If there is a lack of sufficient guidance, feedback, and recovery mechanisms, the immersive experience may instead turn into frustration, weakening the tendency to continue using it ^[10].

In addition to usability, digital museums also need to establish credibility through their interfaces. Due to their functions of disseminating knowledge and providing authoritative explanations, the credibility cues in the interface, such as source and date annotations, curator explanations, image processing instructions, and copyright information, will influence users' judgment of the platform's reliability and further affect their tendencies toward continuous access, sharing, and recommendation. On the other hand, digital cultural services for a broader public are increasingly emphasizing accessibility and support for accessibility, including readability (font size, contrast), multimedia alternative information (subtitles or alternative text), touch-friendly design, and compatibility with low-end devices, etc. These factors jointly determine the coverage and accessibility of the platform in real-usage scenarios ^{[11][12]}.

Although previous studies have provided a wealth of topics and experiential summaries for the interface design of digital museums, there remains a lack of systematic qualitative interpretation based on an interface evidence chain that explains how micro-level interface issues trigger changes in cognitive load, frustration, sense of control, and trust, and further shape visit intention ^[13]. Therefore, this paper starts from the interface layer, combines heuristic evaluation and task walkthrough to conduct structured diagnosis of key pages and task processes, and explains the mechanistic relationship between usability and access intention within the TAM framework, thereby proposing executable optimization suggestions for digital cultural heritage platforms ^{[3][4][6][7]}.

2.2 Usability and Heuristic Evaluation in Design Research

In the context of digital museums, usability is not merely about whether the interface is smooth and easy to operate; rather, it concerns whether users can meaningfully engage with the cultural content. The classic discussion of usability typically centers on effectiveness, efficiency, and satisfaction: effectiveness refers to whether users can achieve key goals (e.g., finding an exhibition entrance, retrieving a target artifact and accessing its details, or obtaining interpretations and supplementary information); efficiency is reflected in the steps, time, and cognitive effort required to achieve the same goal; and satisfaction is often associated with the sense of smoothness, control, and trust experienced during exploration, which in turn influences whether users are willing to continue browsing and revisit ^{[8][14]}.

Among the various usability research methods, heuristic evaluation is a typical inspection method: researchers systematically review the interface against a set of general usability principles, thereby covering multiple pages and modules at lower cost, quickly identifying structural issues, and generating a traceable list of problems ^{[4][5]}. The strength of this approach lies in its efficiency and structured process, making it particularly suitable for research scenarios in which resources are limited but clear design-diagnosis outcomes are needed. However, its limitations are also evident: the evaluation inevitably reflects the

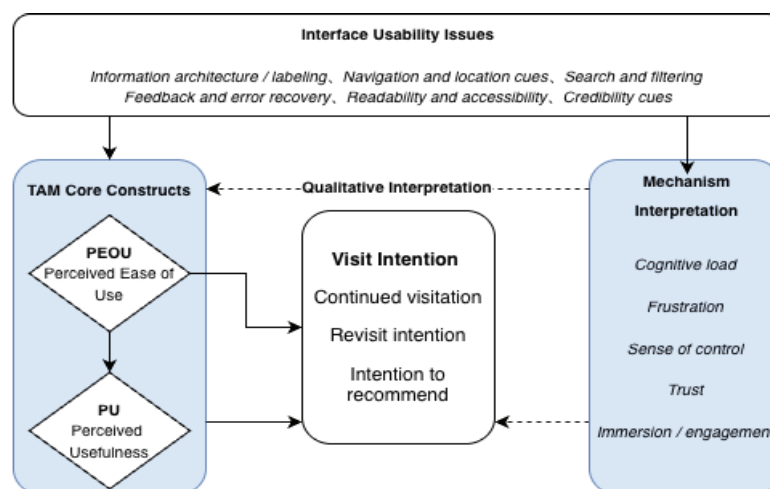
evaluator's perspective, and it cannot directly capture the behavioral choices and interruption reasons of real users in actual task contexts^[5]. Therefore, alongside heuristic evaluation, this paper incorporates task walkthroughs. Using typical tasks as guides, it traces difficulty points and interruption points along critical paths, thereby strengthening the contextual grounding and evidential support of problem descriptions^[6].

2.3 Conceptual Lens: From Usability to Visit Intention

It should be noted that the correlation discussed in this article is not a statistical correlation or regression test. Instead, it constitutes a qualitative mechanistic interpretation based on interface evidence and usability criteria, explaining why these interface issues affect the willingness to continue access. The explanatory pathway begins with interface issues, proceeds through experiential consequences, and further examines their impact on the intention to access^{[15][16]}.

In terms of the explanatory framework, this paper introduces the Technology Acceptance Model (TAM) as a conceptual guideline. User acceptance of a system is typically related to perceived ease of use (PEOU) and perceived usefulness (PU), which further influence behavioral intention^{[3][7]}. In the context of digital museums, usability issues such as information architecture, navigation paths, search and filtering, system feedback, and readability first alter users' judgments of whether the operation is effortless and easy to understand, thereby influencing PEOU. Simultaneously, these issues further change users' judgments of whether the platform is useful and worth investing time in, thereby influencing PU. These judgments are typically perceived and articulated through more specific experiential dimensions, such as fatigue and abandonment due to increased cognitive load, frustration stemming from disorientation and uncertainty, a diminished sense of control owing to insufficient feedback, weakened trust caused by inadequate credibility cues, and immersion and engagement fostered by clear narrative guidance. The resulting experiential consequences further shape users' tendencies toward continued visits, return visits, and recommendations^[13]. Based on this logical relationship, this paper constructs the qualitative conceptual framework shown in Figure 1 to organize the subsequent findings and discussion.

Figure1: TAM-informed conceptual framework with qualitative mechanism interpretation



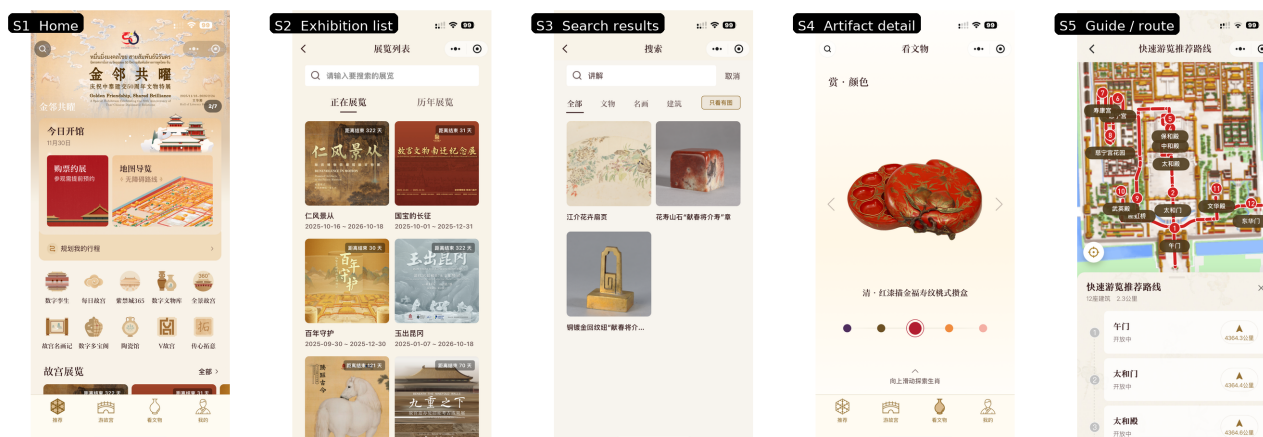
3. Methodology

3.1 Research Design and Scope

This study employed qualitative interface analysis, focusing on the mobile interface of the Digital Palace Museum. To cover users' most common access paths, as shown in Figure 2, which presents the page-type coding scheme with representative screenshots were selected as the analysis scope: the home page (S1), the exhibition list page (S2), the search results page (S3), the artifact detail page (S4), and the integrated tour and route page (S5). All pages were archived as screenshots under a unified evidence coding rule: S1–S5 denote the page type, and the two-digit sequence after the hyphen indicates the screenshot number for that page (for example, S3-02 represents the second evidence screenshot of the search results page). The screenshot collection date was 2025-11-30. During the analysis and recording process, each finding was linked to an evidence screenshot number (S-code), a task step number (T-code), and a page-location description, ensuring that subsequent findings, mechanism discussions, and design suggestions could be traced back to specific interface evidence. Specifically, the

S-code follows the format S page type hyphen screenshot number (for example, S3-02), and the T-code follows the format T task number hyphen step number (for example, T3-2).

Figure2: Page type coding scheme with representative screenshots (S1–S5)



3.2 Task Walkthrough (Cognitive Walkthrough)

To establish a traceable evidence chain, this paper combines two inspection methods, heuristic evaluation and task walkthrough, for interface diagnosis. Heuristic evaluation is employed to systematically identify problem types and their violation patterns across multiple pages. Task walkthrough, in turn, examines how these problems cause comprehension deviations, operational bottlenecks, and potential interruptions along typical task paths, thereby supplementing the contextual factors that a purely heuristic evaluation might overlook^{[4][5][6]}.

In the heuristic evaluation, each of the five key page types was examined individually against Nielsen's ten usability principles. For each identified issue, we documented a description of the problem and its triggering conditions, the corresponding heuristic principle, the page location and screenshot number (S-code, e.g., S3-02), and preliminary improvement suggestions. Subsequently, duplicate entries were removed and similar problems were consolidated to generate a structured list of usability issues. To reflect the potential impact of each issue on task completion, a severity rating scale from 0 to 4 was applied, defined as follows: 0 indicates no problem; 1 indicates a cosmetic or minor issue; 2 indicates a secondary usability problem, which impairs fluency but allows continuation; 3 indicates a major problem, one that significantly increases effort or is likely to induce errors; 4 indicates a critical problem that may lead to task failure or user abandonment.

In terms of task walkthrough (also referred to as cognitive walkthrough), this study establishes six typical tasks (T1–T6), gradually checking whether users can find the entry, understand the meaning, receive clear feedback after an operation, and recover and continue in abnormal situations. For each task step, it records the specific page and control position, system feedback performance, as well as possible breakpoints or decision points (such as an unclear return path, unexplainable filtering results, or a lack of next-step guidance in an empty state, etc.), and links the evidence to a numbered screenshot (S-code). The task step number is represented by a T-code, following the format T-task number-step number (for example, T3-2 represents the second operational step of task T3).

The task settings are as follows:

T1: From the homepage, enter any content module and return smoothly.

T2: Enter the exhibition list and open a specific exhibition entry.

T3: Use the search function to retrieve keywords and access the target entry from the results.

T4: On the artifact details page, obtain key information and interpretive content, and either continue exploring or return.

T5: Enter the tour route page, complete the process of entering, viewing nodes, and finally select the option to continue exploring or return.

T6: Simulate a scenario with no results, a return, or a switch; observe the blank state, error prompts, and the subsequent guidance.

The output of this study includes a list of issues (with severity grading), key breakpoints from the task review, screenshot numbers (S-code) and task step numbers (T-code), as well as preliminary optimization suggestions that can be implemented. The evaluation process is illustrated in Figure 3, and the evidence log table template is shown in Table 1.

Figure3: Evaluation process illustration

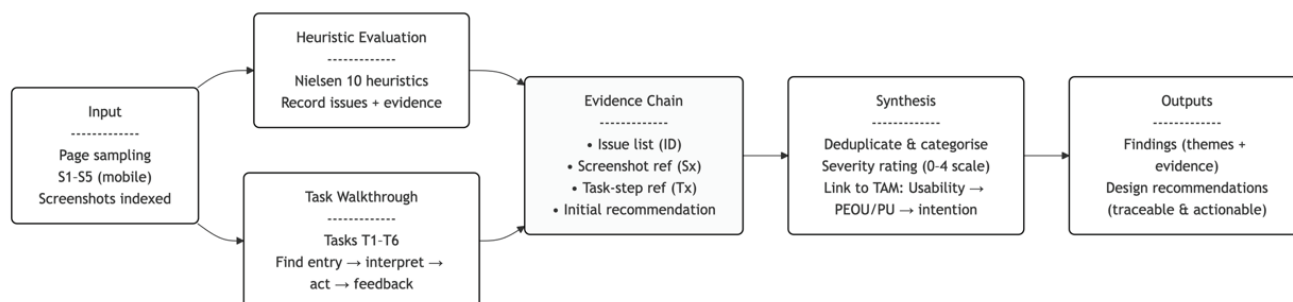


Table1: Extract of evidence log (template)

Issue ID	Page / Position (Sx)	Task step (T1-T6)	Heuristic (Nielsen)	Severity (0-4)	Problem description	Recommendation
H01	S3 / filter bar	T3-2	Match	2	Filter label unclear; scope may be misread	Rename label; show applied-filters summary
H02	S2 / list cards	T2-2	Consistency	1	Date format inconsistent across cards	Unify date format; align with locale
H03	S5 / route list	T5-3	Status visibility	3	Weak progress cue between nodes	Add progress indicator & current-node highlight

Note: Task steps are referenced using T-code (e.g., T3-2 indicates Step 2 of Task 3).

3.3 Qualitative Analysis and Trustworthiness

This study conducts a thematic analysis of the assessment records and evidence screenshots (S-code) in two steps. First, duplicate entries are removed and problem items recorded in both heuristic evaluations and task walkthroughs are merged. These are then classified into problem themes based on their primary manifestations and triggering scenarios: information architecture and labels, navigation and paths, search and discoverability, feedback and error tolerance, readability, consistency, and accessibility, as well as credibility cues. Second, potential experiential mechanism themes triggered by these problem types are refined (e.g., increased cognitive load, heightened frustration, diminished sense of control, shifts in trust, and variations in immersion/engagement). These mechanisms are then correlated with the explanatory pathways of the Technology Acceptance Model (TAM) to elucidate how usability issues affect perceived ease of use (PEOU), perceived usefulness (PU), and access intention^{[3][7]}.

To enhance the research credibility and conclusion traceability, all evidence materials including screenshot codes, issue records, and task-step documentation are retained as an audit trail and subjected to a secondary review. Furthermore, by cross-referencing heuristic evaluation items with key breakpoints identified in the task walkthrough, consistency is verified across two analytical dimensions: violations of usability principles and their observed impact on actual task performance. This triangulation reduces potential bias arising from a single methodological perspective^[17]. Where feasible, inviting peers to conduct random checks and reviews of selected pages and entries is recommended to further strengthen the consistency and reliability of the interpretations.

4. Findings and Discussion

4.1 Usability Issues Overview: Scope and Typology

This study focused on five key pages of the Digital Palace Museum mobile app (S1 homepage, S2 exhibition list, S3 search results, S4 artifact details, and S5 navigation and route integration page), combining them with six typical tasks (T1 to

T6) to form an evidence chain for a structured summary of interface usability issues. Based on the heuristic evaluation and task walkthrough records, usability problems were primarily aggregated into six themes: information architecture and labels, navigation and path visibility, search and discoverability, feedback and error tolerance, readability, consistency, and accessibility, as well as credibility cues. From a distribution perspective, different types of problems manifest differently across pages and task sections: problems related to navigation and paths are more likely to be triggered during cross-page navigation, return hierarchy changes, and state switching; search and discoverability problems are concentrated in the stages of inputting search terms, switching categories, and interpreting results; and feedback and error tolerance-related problems often impact users' ability to continue the task in situations such as empty states or node switching.

To ensure the traceability of the analysis process, during the evaluation stage, each finding was recorded in a sequential and structured format that included the issue, evidence screenshot (S-code), task step number (T-code), corresponding heuristic principle, severity rating (0 to 4), problem description, and preliminary suggestions. Due to space constraints, only an overview summary—listing issue types, covered task steps, corresponding heuristic principles, severity levels, and key evidence screenshot numbers (S-code) is presented in Table 2 in the main text. In the subsequent analysis, evidence screenshot codes (S-code) or task step codes (T-code) are referenced to support the arguments and mechanism explanations.

Table2: Summary of usability issue typology and evidence

Category	Task step (T-code)	Heuristic (Nielsen)	Severity (0–4)	Evidence (S-code)	Key symptom (1 line)
Information architecture and labels	T4-1 T5-1	Match between system and the real world ; Consistency and standards	2	S4-02 S5-02	Labels/CTAs are ambiguous; users may hesitate or misinterpret where to go next.
Navigation and path visibility	T4-2 T5-2 T5-3	Visibility of system statu ; User control and freedom	3	S4-02 S5-02 S5-03	Hidden paths and map occlusion reduce wayfinding; users can feel lost or stuck.
Search and discoverability	T3-1 T3-2 T3-3	Match between system and the real world ; Recognition rather than recall	2	S3-02 S4-03 S3-03	Search scope and result cues are unclear; users struggle to scan and pick the right item.
Feedback and error recovery	T6-1 T3-3	Help users recognize, diagnose, and recover from errors ; Visibility of system status	3	S3-01 S3-03	Empty state and active filters provide weak next-step guidance; abandonment risk increases.
Readability consistency accessibility	T1-1 T4-2	Aesthetic and minimalist design ; Visibility of system status	2	S1-01 S4-03	Small and low-contrast text and dense overlays increase reading effort, especially on mobile.

Note. Evidence codes (S-code, e.g., S3-01) refer to the author's screenshot archive. Task steps are referenced using T-code (e.g., T3-2 indicates Step 2 of Task 3). Screenshot archive (device, app version and capture date) is available from the authors upon request.

4.2 Key Usability Findings: Evidence Based Analysis

Based on heuristic evaluation and task walkthrough, this study categorizes key issues into four dimensions for evidence-based summarization: the observed phenomenon, supporting evidence (S-code), the violated heuristic principle(s), and the resulting experience impact. Overall, usability barriers tend to be magnified in consecutive task chains, for instance, when retrieving details and then returning, or when entering a navigation flow and selecting a node to continue browsing. Specifically, when entry semantics, system status prompts, and the return hierarchy lack clarity, users often resort to trial and error to understand the system. This increases cognitive load and uncertainty, which may reduce perceived ease of use (PEOU) and, through diminished information acquisition efficiency and exploration coherence, further lower perceived usefulness (PU) and the intention to continue visiting.

First, on detail and navigation-related pages, entry or prompt labels are often difficult for users to interpret in terms of expected outcomes (e.g., S4-02, S5-02). Users struggle to predict whether a click will trigger a jump, an expansion, or a content overlay, leading to hesitation and repeated attempts. These issues primarily relate to the heuristics of Match between system and the real world and Consistency and standards. Their experiential consequences include reduced operational efficiency and a weakened sense of control. To improve, clear action-oriented labels, for example using View details, Expand

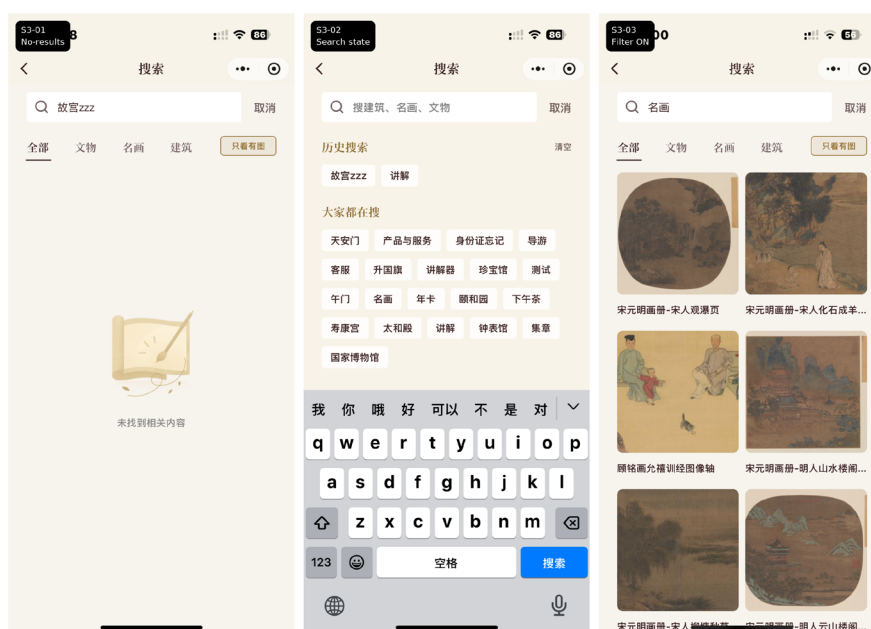
description, or Open pop-up, should be adopted, and brief outcome previews could be provided for key operations.

Second, during search and filtering, scope or conditions are often implicit, and result explanations lack sufficient cues (S3-02, S3-03). When filters are applied without clear indication of active settings or explanations of their effects, users may misinterpret results or overlook items excluded by the filter. This aligns with the heuristics of Visibility of system status and Recognition rather than recall and can reduce scanning and selection efficiency while increasing backtracking. We recommend persistently displaying a filter summary, for example listing scope, keywords, and active filters, in the results area along with a one-click clear option, allowing users to comprehend how the current results were generated without relying on memory.

Third, the state indicating no results tends to signal failure without offering a clear recovery path (S3-01). The page fails to provide actionable next steps, such as clearing the query, modifying keywords, switching search scopes, or suggesting alternative entry points, which readily creates a point of task interruption. This issue aligns with the heuristic Help users recognize, diagnose, and recover from errors and may heighten frustration while diminishing the motivation to continue exploration. It is recommended to position recovery actions as primary button options (e.g., Clear keywords, Switch range or category) and to offer a limited set of operable alternatives (e.g., suggested keywords or popular entry points).

Finally, when map points are densely clustered, labels overlap, and feedback during node transitions is subtle (S5-02, S5-03), the navigation route page elevates the effort required for orientation and route comprehension, thereby impeding continuous progression through the navigation task. This issue relates to the heuristics Visibility of system status and Aesthetic and minimalist design. Mitigation strategies include implementing label aggregation or hierarchical display, emphasizing the current node with highlighting and progress indicators, and providing collapsible panels. These measures collectively aim to lower cognitive load and improve user controllability.

Figure4: Interface Evidence of the Search and Filter Function: Empty State、Input Suggestions and Results Page



4.3 Mechanism Interpretation under TAM

Within the TAM framework, this study conceptualizes the relationship among interface usability issues, experiential consequences, and access intention as a mechanistic correlation. Interface barriers first influence users' judgments of whether the system is effortless and understandable, that is, perceived ease of use (PEOU). When users must repeatedly attempt and fail, frequently backtrack, or struggle to advance steadily through a task sequence, their judgments of whether the platform is worth investing time in and whether it can effectively deliver cultural information, perceived usefulness (PU), are also undermined, thereby reducing intentions for continued access, revisits, and recommendations. Synthesizing the evidence chain presented in Section 4.2, the following mechanisms are observed: unclear entry semantics and ambiguous

return hierarchies primarily impair PEOU by diminishing the user's sense of control and elevating cognitive load; non-explicit search conditions and insufficient explanatory cues in results lower information acquisition efficiency and increase misinterpretation, further eroding PU; the lack of recovery paths in navigation flows more readily creates interruption points, intensifying frustration and sapping the motivation to continue exploring; label overlap and subtle node transition feedback raise the cognitive cost of path comprehension and diminish the potential for immersion and sustained progression. Overall, these mechanisms are not derived from statistically significant causal tests but represent qualitative explanations of user experience outcomes grounded in interface evidence and usability criteria. They serve to illustrate how usability shapes variations in access intention within the mobile digital museum context.

5.Design Implications and Recommendations

Based on the findings and mechanistic explanations above, this paper proposes optimization recommendations for the Digital Palace mobile interface, with the objectives of reducing trial and error costs, enhancing state visibility and path controllability, and thereby improving users' continuous progression during search, comprehension, and navigation.

First, concerning entry semantics and consistency issues, it is advisable to adopt predictable naming for key operations by combining verbs with expected outcomes and to standardize the wording and presentation of similar entry points to minimize on screen semantic overlap. For operations that alter page layout, brief outcome cues such as expand, jump to, or open pop up should be provided to help users establish stable operational expectations.

Second, to improve the discoverability of search and filtering functions, a persistent summary of applied conditions, for example scope, keywords, active filters, should be displayed within the results area, accompanied by a one click option to clear all filters. For restrictive filtering strategies such as only show images, the system should explicitly indicate their impact, for instance, noting the reduction in result count or the hiding of non image entries, to reduce misunderstanding and the need for backtracking.

Third, to address insufficient feedback and error tolerance, the empty result state should be redesigned from a passive failure notification into an active recovery pathway. Primary level recovery actions, such as clear keywords or switch range or category, should be presented as prominent buttons, supplemented by a limited set of actionable alternatives such as suggested keywords, popular entry points, or a link back to recommended content, thereby lowering the likelihood of task abandonment.

Finally, regarding path comprehension and visual clutter challenges in the navigation route, map congestion can be alleviated through tag aggregation or hierarchical labeling. The current node should be distinctly highlighted with a progress indicator, and collapsible side panels along with recovery functions, such as return to current node or center on current view, should be provided to strengthen controllability and browsing continuity.

Conclusion

This study takes the Digital Palace Museum mobile application as its research object. By integrating heuristic evaluation and task walkthrough, it performs evidence-based analysis of key pages and typical task chains, and identifies key issue types including inconsistent entry semantics, ambiguous search conditions and result explanations, missing recovery paths in empty states, and poor readability and feedback in navigation routes. Furthermore, from a TAM perspective, it systematically explains how usability issues influence perceived ease of use (PEOU), perceived usefulness (PU), and visit intention through experiential consequences such as increased cognitive load, reduced sense of control, and heightened frustration. The findings offer actionable optimization directions for improving the interfaces of digital cultural heritage platforms, highlighting the importance of foundational interaction qualities, specifically visible system states, controllable navigation paths, and recoverable error states, in mobile contexts for sustaining user engagement. Given the methodological and scope limitations, this paper presents qualitative interpretations grounded in interface evidence and usability criteria. Future research could incorporate actual user testing and longer-term usage scenarios to further validate and extend the findings regarding task performance and sustained usage behaviors across different user groups.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research on the Training Paths of Foreign Language Talents in Vocational Undergraduate Universities Under the Background of New-Quality Productive Forces: A Case Study of a Vocational Undergraduate University in Shandong

Xiaofei Wei*, Hui Dou, Hanyue Zeng

School of Foreign Language, Shandong Vocational and Technical University of International Studies, Rizhao, 276800, China

*Corresponding author: Xiaofei Wei, 1023197314@qq.com

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Abstract: The development of New-Quality Productive Forces (NQPF) has emerged as a core driver of China's high-quality economic growth, generating an urgent demand for high-caliber compound foreign language talents equipped with technical and vocational competencies. As a pivotal link connecting the education, talent, industrial, and innovation chains, vocational undergraduate universities play an indispensable role in cultivating such talents to underpin NQPF advancement. However, the current foreign language talent training in these universities faces prominent challenges, including ambiguous orientation, inadequate practical teaching, insufficient industry-education integration, and simplistic evaluation mechanisms, resulting in a mismatch between graduates' capabilities and industrial needs. Employing a qualitative case study approach, this research focuses on the Applied English program at a vocational undergraduate university. By analyzing relevant literature and data, it identifies the core dilemmas in talent cultivation and proposes a five-dimensional optimization framework. The study aims to provide practical pathways for nurturing foreign language talents with solid linguistic proficiency, industry-specific expertise, and digital capabilities, thereby supporting the international upgrading of industries and the sustainable development of NQPF.

Keywords: New-Quality Productive Forces; Vocational Undergraduate Education; Foreign Language Talent; Talent Training

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1.Introduction

The concept of New-quality Productive Forces (NQPF), first proposed by President Xi Jinping in September 2023, refers to an advanced form of productive forces driven by revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth industrial transformation and upgrading^[1]. It serves as a critical guideline for high-quality development in China, emphasizing the integration of technological innovation, industrial innovation, and talent development. The 15th Five-Year Plan, adopted in October 2025, further highlights the strategic importance of accelerating self-reliance in high-level science and technology, fostering NQPF, and enhancing the capacity of vocational education to serve industrial needs.

1.1 Research Background and Significance

In the context of NQPF, globalization and digitalization have intensified the demand for compound foreign language talents who can bridge international technical exchanges and industrial cooperation. These talents are expected to combine proficient foreign language skills with cross-cultural communication capabilities, digital literacy, and industry-specific expertise to adapt to scenarios such as cross-border trade, digital economy, and international technical collaboration. Vocational undergraduate universities, as the main providers of high-level technical and skilled talents, are tasked with aligning their training models with the evolving needs of NQPF. However, existing foreign language training in these institutions often fails to meet industrial requirements, creating a talent gap that hinders industrial internationalization. Thus, exploring effective training paths for foreign language talents in vocational undergraduate universities under the NQPF background is of great practical significance for promoting the integration of education and industry, and supporting national strategic development.

1.2 Research Objectives

This study aims to address the aforementioned research gaps. By conducting a systematic review of relevant literature and carrying out field investigations, it identifies the higher requirements for foreign language talents in vocational undergraduate universities under the background of NQPF, as well as the gaps between current training models and such requirements. It further constructs a holistic optimization framework to resolve the core dilemmas in talent cultivation, and provides actionable and targeted recommendations for vocational undergraduate institutions, industrial enterprises, and educational policymakers.

2. NQPF and Foreign Language Talent Cultivation

NQPF has reshaped industrial demand for compound foreign language talents and pushed vocational undergraduate education toward reform, with existing research echoing the need for practice-oriented and technology-integrated training. However, the actual foreign language training in these institutions fails to keep pace with such demand and reform trends, presenting systemic mismatches across multiple dimensions rather than isolated issues.

2.1 An Overview of NQPF

The global shift toward digitalization, cross-border collaboration, and technological innovation has catalyzed the emergence of NQPF—a concept defined by revolutionary technological breakthroughs, innovative allocation of production factors, and in-depth industrial transformation. As a core driver of China's high-quality economic growth, NQPF has been formally elevated to a national strategic priority: the 15th Five-Year Plan (2025) explicitly emphasizes accelerating the integration of scientific and technological innovation with industrial development. Besides, Erik Baark, Honorary Professor in the Department of Social Science at the Hong Kong University of Science and Technology, stated that China defines the development of advanced productive forces as the pursuit of higher technological content. This implies that China needs to accelerate technological innovation to advance the development of new quality productive forces^[2]. David Monyae, Director of the Center for Africa-China Studies at the University of Johannesburg in South Africa, pointed out that the proposal of new quality productive forces reflects a shift in the perception of China regarding the role of technology in the economy and the broader modern society^[3], and they firmly believe that technology and innovation can become the core productive forces.

It is evident that NQPF, incubated against the backdrop of global digitalization, cross-border collaboration and technological innovation, is characterized by revolutionary technological breakthroughs and other core attributes, serving as a pivotal engine for China's high-quality economic development. Overseas scholars have affirmed its value, noting that it reflects China's emphasis on technological innovation and the shifted perception of technology's role.

2.2 NQPF-Driven Foreign Language Talent Cultivation

It is imperative to accelerate the in-depth integration of scientific and technological innovation with industrial development and position vocational education as a critical link that connects the “education chain”, “talent chain”, and “industrial chain”. Behind this strategic positioning lies a profound trend: NQPF are no longer confined to the economic realm; instead, they have evolved into a transformative force reshaping the demand for human capital, exerting a far-reaching impact particularly on fields characterized by both cross-cultural attributes and technical collaboration requirements, such as foreign language services.

For vocational universities, the phenomenon of NQPF-driven talent demand manifests in two key trends. First, industries

closely tied to NQPF increasingly seek compound foreign language talents—individuals who combine linguistic proficiency with digital literacy, industry-specific expertise, and cross-cultural problem-solving skills. Hu Yingmei noted that NQPF rejects “single-skill” labor and instead demands talents who can “adapt to dynamic industrial scenarios, apply new production tools, and create innovative value”^[4]. Second, vocational undergraduate education—tasked with cultivating high-level technical and skilled talents—faces mounting pressure to align its curricula and training models with these industrial needs. Feng et al. highlight that vocational undergraduate institutions must move beyond traditional “theory-heavy” models to prioritize practical, industry-integrated training, as their role in supporting NQPF lies in “translating technological innovation into actionable workforce capabilities”^[5].

Existing research has increasingly recognized the need for reform, yet it suffers from insufficient interdisciplinary integration. Studies by some scholars propose initiatives such as integrating digital technologies and adopting project-based learning, but these efforts remain confined to superficial applications rather than in-depth interdisciplinary convergence. In contrast, Wang and Zhou have applied activity theory to analyze how AI and big data reshape foreign language teaching mechanisms, revealing the interactive relationships between teaching subjects, tools, and rules^[6]. Similarly, Wang Zhuli’s “on-demand learning paradigm” demonstrates how educational technology can integrate with vocational foreign language teaching to enhance learning adaptability^[7]. Despite their insights, these interdisciplinary findings have not been fully leveraged in current research.

International experience offers valuable insights for addressing these gaps. Germany’s dual vocational training system integrates classroom instruction with enterprise-led practical training, nurturing foreign language skills through real-world project participation, with approximately two-thirds of trainees securing employment with their training companies—a testament to its effective industry integration^{[8][9]}. Australia’s Technical and Further Education system adopts competency-based foreign language curriculum design, offering short courses tailored to industry needs^[10]. Global research on digital technology empowerment, such as studies on “digital technology-enabled vocational foreign language teaching” and “cross-border collaborative language service talent training”, underscores the importance of adaptive learning platforms and cross-cultural communication simulations^[11]. These perspectives can provide a framework for identifying the unique context of NQPF in China while leveraging universal best practices.

To sum up, NQPF, a national strategic priority for China’s high-quality growth, reshapes demand for compound foreign language talents with linguistic, digital, industrial and cross-cultural competencies, pushing vocational undergraduate education to reform. While research confirms reform needs and international experiences offer references, systemic mismatches (theory-practice disconnection, superficial integration) persist. Future efforts should integrate interdisciplinary insights and global practices to deepen collaboration and optimize systems, aligning training with NQPF demands.

3. Methodology

This study takes the Applied English major of a vocational college in Shandong Province as the research object. As a representative vocational undergraduate major with a history of over 20 years in running programs, it has an enrollment scale of more than 20,000 students and has established extensive cooperative relationships with dozens of enterprises in the fields of cross-border trade, language services and digital marketing. Three criteria were followed for case selection: first, the professional orientation is highly consistent with industries related to NQPF; second, complete and accessible data resources are available, including talent training programs, course syllabi, graduate employment records and other materials; third, it presents typical dilemmas in foreign language talent training in vocational undergraduate colleges. To systematically explore the talent training practice of this major, this study integrates multiple specific research methods and conducts targeted research around core research dimensions, which are detailed as follows.

3.1 Literature Research Method

As the basic data collection method of this study, the literature research method systematically sorts out and analyzes various official documents and materials to obtain objective basic data support. The research objects include talent training programs from 2021 to 2025, syllabi of core courses, faculty files, school-enterprise cooperation agreements and graduate employment reports from 2022 to 2025.

3.2 Semi-Structured Interview Method

To obtain in-depth subjective data and make up for the limitations of literature research, this study adopted the semi-structured interview method and selected 15 key stakeholders as interviewees, including 5 university and department-level teaching administrators, 6 backbone teachers with more than 5 years of teaching experience, 2 industry mentors from cross-border e-commerce and language service enterprises, and 10 fresh graduates employed in international technical services and cross-border marketing positions. Each interview lasted 45-60 minutes. With the consent of the interviewees, the interviews were recorded and transcribed verbatim to ensure data integrity.

3.3 Classroom Observation Method

To obtain first-hand empirical data on the teaching implementation process, this study employed the classroom observation method, selecting 8 core courses as observation objects and designing a structured observation scale. The observation focused on recording key information around the courses and practice dimension while taking into account the relevant performance of other dimensions.

3.4 Case Study Method

As the overall research paradigm of this study, the case study method integrated the research results of the literature research method, semi-structured interview method and classroom observation method, taking the Applied English major of a vocational college in Shandong Province as a single case.

Through literature research, the “design-level” characteristics of the talent training system were clarified; through semi-structured interviews, the “cognitive-level” feedback from various subjects on training practice was explored; through classroom observation, the “operation-level” performance of teaching implementation was captured. The analysis results of the three levels of data were mutually verified and supplemented, forming a comprehensive understanding of the talent training practice of this major.

4. Research Findings

Based on a multi-dimensional analytical framework and multi-source data triangulation, this study summarizes the current development status of the Applied English major at a vocational college in Shandong Province. The advent of the new-quality productivity era, characterized by innovation-driven development, digital transformation, and deep industry-education integration, has raised higher requirements for talent cultivation in vocational undergraduate education. In particular, the Applied English major is expected to foster compound, practical, and innovative talents capable of adapting to the digital and intelligent development of related industries. However, the current development of this major still has a certain gap with the higher requirements of new-quality productivity, which is manifested in the following aspects.

4.1 Ambiguous Talent Training Orientation

The talent cultivation model of the major still replicates the “theory-heavy and practice-light” approach adopted by general undergraduate institutions. This model not only fails to highlight the core characteristics of vocational education, but also deviates from the demand for compound talents driven by new-quality productivity. Such talents should be proficient in English application, skilled in digital tools, and well-acquainted with emerging industries. Three core mismatches between the current training model and actual demand are identified as follows.

First, the proportion of practical course hours is insufficient and the course content is disconnected from digital industrial scenarios. Practical teaching is mainly limited to classroom simulations and does not cover training on core digital skills. Second, the teacher-centered teaching model lacks digital practice activities conducive to improving students’ practical abilities. Third, less than 15% of graduation thesis topics are related to the field of new-quality productivity, while most of the topics focus on traditional academic research directions.

4.2 Insufficient Implementation Effect of Practical Courses

Although the major has added digital courses to its traditional curriculum system, the implementation effect of these courses is far from meeting the requirements of new-quality productivity, resulting in a mismatch between training content and the needs of digital industrial positions.

The teaching of digital courses still relies heavily on teacher demonstrations. Classroom observations show that in AI-aided

translation courses, teachers only explain and demonstrate the basic operation of tools, and students merely take notes and conduct simple practice. Practical activities are confined to classroom exercises, without in-depth practical tasks such as real translation projects. Students can only use simplified software for simulation operations in class, with no access to real business platforms such as language service enterprise systems. As a result, they cannot participate in daily business processes in the new-quality productivity era. Enterprise mentors confirmed that graduates need 3 to 6 months of on-the-job training to adapt to digital positions, especially lacking core skills. This situation directly indicates that the current practical courses have failed to achieve the training goal of “zero-distance connection with digital positions” required by new-quality productivity.

4.3 Lagging Faculty Development

The insufficient number of digital “double-qualified” teachers, who possess both solid professional theoretical knowledge and practical experience in the digital industry, has become a core bottleneck restricting the quality of talent cultivation^[12]. New-quality productivity requires teachers to have the ability to integrate digital technology into the teaching process, but the current faculty team has not yet formed such supporting capacity.

The survey results show that, over 70% of professional teachers are newly graduated academic postgraduates. Although they have a solid theoretical foundation, they generally lack practical experience in the digital industry. Their enterprise practice is mostly short-term, lasting only 1 to 2 months, which makes it impossible for them to master cutting-edge industry technologies, let alone integrate digital practical content into classroom teaching. In addition, part-time enterprise mentors employed by the college are mostly technical backbones in the digital industry, but they lack systematic training in teaching capabilities, and thus cannot transform their rich industrial experience into teachable course content. The selection, training and development mechanism for digital “double-qualified” teachers is yet to be improved.

University-enterprise cooperation remains at a superficial stage and fails to build a collaborative ecosystem for digital talent cultivation required by new-quality productivity. New-quality productivity demands that both universities and enterprises participate in the entire process of talent cultivation, but the current cooperation model lacks such in-depth synergy.

4.4 Insufficient Depth of Industry-Education Integration

A backward inference based on indicators such as the employment direction and employment rate of graduates majoring in foreign languages shows that university-enterprise cooperation in foreign language majors mostly stays at the level of superficial connection such as internship recommendation and position placement. There is a lack of in-depth collaborative models involving joint research on curriculum standards, co-construction of teaching content, co-design of training projects and joint cultivation of talents, failing to form a closed-loop of “industry-university-research-application” integrated talent cultivation.

4.5 Undiversified and Rigid Evaluation System

Most courses adopt an assessment model consisting of 60% final examination scores and 40% regular performance scores. The final examination focuses on traditional theoretical knowledge such as grammar and literary translation, while regular performance only includes homework submission and attendance. Core digital abilities are not included in the assessment scope.

Both teachers and enterprise mentors pointed out that there is a lack of systematic assessment standards for students’ practical performance in digital positions, and there is a serious mismatch between graduates’ academic scores and their digital abilities at work. This single evaluation orientation cannot effectively guide students to focus on improving their digital skills, nor can it accurately assess the effectiveness of talent cultivation oriented to new-quality productivity.

5. Optimization Paths for Foreign Language Talent Training Under the Background of NQPF

The paths focus on “talent positioning, practical ecology, faculty development, university-enterprise collaboration, and evaluation system”—five core dimensions, aiming to realize the transformation from “knowledge-oriented training” to “competency-oriented training” and build a talent training system that is compatible with NQPF development needs.

5.1 Clarify the Orientation of “Foreign Language +” Compound Application-Oriented Talents

The advent of new-quality productive forces has fostered emerging job roles such as cross-border digital marketing

and language model training. However, the conventional model of foreign language talent cultivation is plagued by the predicaments of ambiguous positioning, singular competency profiles, and superficial practical training—it focuses exclusively on the imparting of linguistic and literary knowledge while neglecting industry-critical competencies including technological adaptability and cross-disciplinary collaboration. To address the dilemma of ambiguous training orientation and the “theory-heavy, practice-light” model, this path focuses on reconstructing the training system with “compound competency” as the core and “practical empowerment” as the means.

Specific measures cover five aspects: First, standardize curriculum content. Taking the Applied English major as an example, the curriculum system should be restructured to quantify practical course hours—requiring that practical teaching hours, including project training, simulation operations and real case analysis, account for no less than 40% of professional core courses. Part of the original theoretical hours should be transformed into “theoretical explanation plus immediate practice” modules, and the learning effect of practical hours should be integrated into the formative evaluation system. Second, reform practical forms. Based on the cognitive apprenticeship model, a “classroom workshop” mode should be implemented. Arranging courses such as translation and cross-border e-commerce English in training rooms equipped with professional software to integrate teaching and training^[13]. Adopt “project-based homework”: replace traditional written homework with micro-projects from cooperative enterprises, such as product description translation, overseas social media content creation and customer email handling simulation, which are completed by students in groups and evaluated jointly by enterprise mentors and professional teachers. Third, add “professional direction module courses”. In the second semester of the sophomore year or the junior year, set up micro-major modules such as “technical document translation”, “cross-border digital marketing” and “language model trainer”. Students can choose 1-2 modules and complete all courses and training projects in the selected modules. Fourth, emphasize practicality in graduation theses. Students can write graduation designs or investigation reports based on their internship experience to solve real practical problems and put forward effective solutions or process optimization plans. Fifth, promote interdisciplinary integration and professional transformation. Through “foreign language + AI/technology” and “foreign language + specific field/industry” models, break the barriers of traditional foreign language majors and reshape professional value and competitiveness by integrating with other disciplines.

5.2 Build a Practical New Ecology of “Real Projects + Interdisciplinarity”

Aiming at solving the problem of insufficient implementation of practical courses and the disconnection between training and industrial reality, this path focuses on building a practical ecology that integrates “real scenarios, real projects, and interdisciplinary collaboration”. Two key measures are proposed: First, introduce real enterprise projects into the classroom. Sign agreements with cooperative enterprises to take part of their non-core but real businesses as daily training content, which are completed under the guidance of teachers and enterprise mentors. Enterprises pay according to quality or provide certifications, enabling students to gain real work experience and rewards or certificates. Second, establish interdisciplinary project workshops. Cooperate with the school’s colleges of computer science, finance, and design to set up “digital product going global workshops” and “international integrated media content creation workshops”. Foreign language majors are responsible for language, culture, and market analysis, while students of other majors are responsible for technology, design, and operation to jointly complete interdisciplinary projects and simulate real workplace collaboration. In addition, driven by these workshops, students can jointly participate in skill competitions and innovation and entrepreneurship competitions to promote learning through competition.

5.3 Strictly implement “Dual-Qualified” Faculty Development Mechanism

To address the inadequacies of the “dual-qualified” faculty team, this path focuses on building a two-way flow mechanism between the university and enterprises and realizing hierarchical empowerment of faculty. Two key measures are formulated: First, send no less than 20% of professional course teachers to cooperative enterprises for “on-the-job practice” in full-time or part-time form every academic year, with a duration of at least 2 months. Teachers should undertake specific work tasks and sign a task book, and enterprises should issue a practical ability appraisal report at the end of the practice. Second, hire a group of experienced business backbones or managers with willingness to teach from cooperative enterprises as industrial mentors. Instead of giving occasional lectures, industrial mentors are required to undertake the teaching of a practical course

for at least 32 class hours. In addition, they should jointly guide graduation designs or theses with on-campus teachers and participate in revising curriculum syllabi and training manuals. Systematic “teaching methodology” workshops should be held for industrial mentors, covering curriculum design, classroom management, teaching skills, and assessment and evaluation, which are taught by senior on-campus teaching experts to improve their teaching effectiveness.

5.4 Promote the Construction of a University-Enterprise Collaborative Education Community

To solve the problem of insufficient depth of industry-education integration, this path focuses on building a community of shared interests with “benefit sharing and process co-management” as the core, and proposes three key measures: First, establish a “professional construction committee”, requiring that experts from industries and enterprises account for no less than 40% of the committee members. The committee not only provides consulting services but also has the right of review and veto over talent training programs and core curriculum standards to ensure that the training direction is closely aligned with industrial needs. Second, jointly build “on-campus productive training bases”. Cooperate with leading enterprises to build physical or virtual institutions with both operation and teaching functions on campus, such as cross-border live broadcast incubation centers and language service studios. Enterprises provide projects, technologies, and part of the operation support, while the university provides venues, equipment, and student teams. Profits are shared according to agreements to achieve self-sustainability. Third, jointly develop teaching resource packages. Cooperate with enterprises to compile loose-leaf textbooks based on real cases, develop online training course packages, and establish enterprise real corpus and project databases, directly transforming enterprise work standards into teaching standards.

5.5 Establish a Comprehensive Evaluation System

To address the dilemma of a single evaluation system, this path focuses on building a comprehensive evaluation system that integrates process tracking, multi-dimensional assessment, and industry-education collaboration, with two key measures: First, reform the course assessment method. Significantly reduce the proportion of final closed-book exams, and increase the weight of assessment forms such as project defense, practical operation assessment, work review, and simulated scenario performance. In addition, introduce enterprise evaluation—for project courses and internships, the evaluation of enterprise mentors should account for no less than 30%-50% of the total score. Second, introduce the third-party competency certification. Integrate industry-recognized vocational skill level standards into course assessment, encourage students to participate in authoritative third-party competency certifications, and use certification results as an important reference for course completion or graduation.

The above five optimization paths form a systematic and mutually reinforcing improvement framework. Clarifying talent positioning provides a direction for the reform; building a practical ecology provides a carrier for ability training; constructing a “dual-qualified” faculty team provides human support; establishing a university-enterprise collaborative community provides institutional guarantee; and establishing a comprehensive evaluation system provides a feedback mechanism. Together, they address the core dilemmas of foreign language talent training in vocational undergraduate institutions and provide actionable solutions for adapting to the talent demand of NQPF.

6. Conclusion

6.1 Research Summary

This study focuses on the talent training of foreign language majors in vocational undergraduate institutions under the background of NQPF, and systematically explores the core dilemmas and optimization paths through qualitative case study on the Applied English major of a vocational college in Shandong Province. The research conclusions and prospects are summarized as follows.

First, the development of NQPF has put forward higher and more compound capability requirements for foreign language talents in vocational undergraduate institutions. Vocational education must transform to cultivate “new-quality” technical and skilled talents with high innovative literacy to meet the demand of NQPF. The case study confirms that foreign language talent training in vocational undergraduate institutions currently faces five interrelated core dilemmas: ambiguous training orientation, insufficient implementation of practical courses, inadequate faculty development, insufficient depth of industry-education integration, and undiversified evaluation system. These dilemmas collectively lead to the mismatch between

talent output and the compound capability requirements of NQPF, highlighting the urgency of training model reform. Second, the five optimization paths proposed in this study form a systematic solution to address the above dilemmas. Clarifying the “Foreign Language +” compound application-oriented talent orientation clarifies the core direction of reform; building a practical ecology of “real projects + interdisciplinarity” provides a carrier for capability cultivation; improving the “dual-qualified” faculty development mechanism strengthens human resource support; deepening the university-enterprise collaborative education community ensures institutional synergy; and establishing a comprehensive evaluation system provides an effective feedback and incentive mechanism. These paths are mutually reinforcing and targeted, which can systematically promote the reform and innovation of talent training models, and provide solid talent support for the sustainable development of NQPF.

6.2 Implications

Looking forward, foreign language education in vocational undergraduate institutions should more proactively integrate into national development strategies and industrial upgrading. On the one hand, it is necessary to dynamically adapt to technological changes such as digital economy and artificial intelligence, and more closely integrate cutting-edge technological tools with teaching practice—for example, further exploring the application of large language models in translation teaching and cross-border business simulation. On the other hand, it is essential to expand the international perspective of talent training, strengthen intercultural communication and global competence cultivation, so as to adapt to the increasingly frequent international cooperation needs under NQPF.

In conclusion, by constructing a more resilient, open and forward-looking talent training system, foreign language education in vocational undergraduate institutions will not only effectively empower NQPF, but also contribute key strength to China’s gaining advantages in global competition. This study enriches the research on foreign language talent training in vocational education under the new economic background, and the proposed optimization paths have certain practical reference value. However, the research is limited to a single case, and future research can expand the scope of cases to verify the universality of the conclusions and further explore the differentiated paths for different types of foreign language majors.

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Research on a Multidisciplinary Talent Development Model for High-End Shipping Services

Ming Sun¹, Shiyun Xu¹, Kebiao Yuan^{2*}, Midakpe P. Vortia¹

1.College of Transport and Communications, Shanghai Maritime University, Shanghai, 201306, China

2.School of Economics and Management, Ningbo University of Technology, Ningbo, 315211, China

*Corresponding author: Kebiao Yuan, ykbjob@163.com

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Abstract: The global shipping industry is undergoing significant changes driven by digitalization, green and low-carbon development, and shifting geopolitical dynamics. These shifts create an urgent need to upgrade high-end shipping service talent from single-skill specialists to multidisciplinary professionals. However, traditional talent cultivation models face structural challenges, including rigid disciplinary barriers, weak collaborations between universities and industry, and slow response mechanisms to emerging needs. In response, this study proposes a C-P-R-I talent cultivation model which is centered on Curriculum Integration (C), Practice Driving (P), Responsive Mechanism (R), and Integrated Empowerment (I). This model restructures the knowledge framework through modular courses integrating shipping, management, finance, law and information technology.” It strengthens practical learning through a dual approach of case studies and projects, supported by a hybrid virtual-physical practice platform. Additionally, it introduces a dynamic optimization mechanism based on industry-education alliances to improve students’ interdisciplinary abilities and professional capabilities. By offering an adaptable and feasible innovation pathway, this research seeks to provide theoretical support and practical guidance for advancing high-quality development in the shipping services sector and for promoting innovation in higher education talent cultivation.

Keywords: High-End Shipping Services; Multidisciplinary Integration; Talent Cultivation Model; C-P-R-I Model; Deep Industry-Education Integration

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1.Introduction

1.1 Research Background and Importance

The global shipping industry is undergoing profound transformation driven by digitalization, green and low-carbon transition, and geopolitical realignment. In this context, the competitiveness of international shipping hubs now depends not only on port infrastructure and throughput scale but increasingly on high-end knowledge-intensive service capabilities such as shipping finance, maritime arbitration, and digital governance. Although major Asian ports like Shanghai perform strongly in container throughput (surpassing 50 million TEUs in 2024) ^[1], they continue to lag behind global shipping hubs like London and Singapore in terms of soft power capabilities. Geopolitical conflicts, shifting trade policies, and carbon reduction targets have also collectively disrupted traditional operational models, increased costs and accelerating technological evolution. These

changes require advanced talents with more comprehensive skill sets. The industry no longer seeks only operationally skilled individuals; it urgently needs multidisciplinary professionals capable of integrating knowledge across fields to tackle complex and evolving challenges.

1.2 Research Objectives

Shipping education currently remains predominantly single-discipline, facing persistent problems such as rigid disciplinary barriers, weak links between theory and practice, and slow responses to industry demands, making it difficult to meet the needs for new talent. Therefore, grounded in the industry's real-world challenges, this paper proposes a multidisciplinary training model built on a modular curriculum that integrates "shipping + management + finance + law + information". Supported by a dual-drive teaching approach that combines case studies and projects with a blended virtual-physical practice platform, the study systematically enhances professional competence, offering a practical reference for the development of high-end shipping services and promoting innovation in higher education systems.

2. Research Status

2.1 The essence of High-End Shipping Services and Talent Demand

High-end shipping services have become the core competitive focus for global shipping hubs. Their scope has expanded from traditional ship brokerage and insurance to more knowledge-intensive domains such as shipping finance, maritime arbitration, and digital governance. This evolution not only shows business expansion but also reflects a nation's comprehensive level of shipping soft power. London's long-standing status as a leading global shipping center is supported by its advanced clusters of high-value-added services such as shipping finance, shipbroking, marine insurance, litigation, and arbitration, which collectively form the foundation of its soft ^[2]. Similarly, these trends can be observed in China's shipping factor market practices. Major shipping exchanges in Shanghai, Guangzhou, Wuhan, and Ningbo have comprehensively extended their business scope from vessel asset transactions to high-end value-added services including freight index derivatives, shipping fintech, blockchain data platforms, and green financial products ^[3]. Simultaneously, comparisons with international best practices in Hong Kong and Singapore reveals that building a comprehensive ecosystem covering green fuels, carbon finance, digital governance, and integrated derivatives trading, represent the leading direction for global high-end shipping services development.

The deepening of these concepts and the emergence of new business models further highlight the urgent need for high-end multidisciplinary talent. The effective provision of high-end services heavily relies on expert teams capable of bridging shipping, finance, law, and information technology. Intelligent shipping faces technical challenges such as data security, integration of multi-source heterogeneous data, and limitations of AIS data ^[4]. Meanwhile, advancing green ports is constrained by high infrastructure costs, inconsistent technical standards, and conflicts between operational efficiency and emission reduction targets. Addressing these complex issues cannot be achieved by professionals from a single discipline. Instead, the industry requires multidisciplinary experts with a cross-field knowledge structure that combines "shipping + intelligence + green" capabilities. Also, China is transitioning from being a "follower" to a "rule-shaper" in the global high-end shipping services market, with the bottleneck being the shortage of such multidisciplinary talent. Consequently, establishing a stable and credible institutional framework aligned with international standards and cultivating a talent pool has become decisive factor to determining the development level of a shipping hub ^[5].

While existing research ^[6] clearly outlines the market demand and strategic value of high-end shipping services, it largely treats these outcomes as a predetermined industrial goal. The underlying mechanisms and practical pathways for systematically cultivating, through educational reforms, a scalable group of versatile professionals capable of both delivering and advancing these high-value services remain significantly underexplored.

2.2 Structural Transformation in Shipping Talent Demand

The global shipping industry is experiencing a fundamental shift toward green technologies and intelligent operations, which is reshaping its talent requirements. There is an increasing talent demand for professionals with multidisciplinary, composite competency structures. Supply-demand imbalance also exists for high-level, multidisciplinary shipping talent as a forming a key constraint on the industry's sustainable development ^[7]. Empirical evidence illustrated in Figure1, indicates

that the talent currently required by the industry must possess cross-disciplinary knowledge backgrounds or work experience. Their competency dimensions must span multiple related fields including shipping finance, logistics management, shipping economics, maritime law, shipping information, and shipping transactions. Among these, data and digital skills (80%) and green technology and ESG compliance (65%) have emerged as the most prominent capability gaps. These multidimensional competency requirements significantly exceed the scope of traditional single-discipline training frameworks, underscoring the urgency of advancing interdisciplinary education.

Figure1: Distribution of Areas with “Significant Skill Gaps” Reported by Shipping Companies



Amid this transformation, the rapid advancement of technologies such as Artificial Intelligence (AI) has become a key force reshaping talent competency framework. The ports and shipping sector accelerate their digital and intelligent transformation, demand for highly skilled professionals continues to rise, while traditional classroom-centered teaching models struggle to meet industry's evolving needs^[8]. As a result, a micro-professional training and management system guided by the principles of interdisciplinary collaboration, coordinated education, and demand orientation was proposed to counter this challenge^[9]. This framework aims to precisely meet the new competency requirements posed by the trends toward green, intelligent, and unmanned shipping. Recent studies further refined this competency framework^[10], advocating that maritime universities systematically restructure their curricula, teaching objectives, and content to cultivate interdisciplinary talents possessing three core skill sets: “maritime + intelligent,” “maritime + green,” and “maritime + cross-domain.”

Given these fundamental shifts in competency structures, talent cultivation strategies must undergo parallel reform. Survey research^[11] highlights that shipping enterprises and institutions highly require a transition from traditional single-skill models to demand-driven, diversified pathways emphasizing international perspectives, interdisciplinary capabilities, and deep industry-education integration. It was also confirmed that the shipping industry has seen significant increases in both the quantity and quality of talent demand, rendering traditional training methods inadequate to meet market needs^[12]. Based on this, they explored interdisciplinary training models and supporting systems at the undergraduate and graduate levels within higher education institutions. From the educational philosophy level, the shipping industry transitions was argued on from extensive to intensive development, integrating shipping-specific curricula with ideological and political theory is essential to strengthen the sense of responsibility and mission among talents aspiring to build a maritime powerhouse^[13]. Notably, improving the strategic value of talent also demands innovation in organizational learning cultures. Empirical research reveals that talent contributes even more significantly to sustainable performance than leadership within shipping companies^[14]. Their findings highlight that building a “learning-oriented” organizational culture is a key approach to effectively nurturing and developing shipping talent.

As evidenced above, existing research has formed an essential consensus on the kind of talent the industry needs:

interdisciplinary professionals with cross-disciplinary knowledge, international perspectives, and innovative practical capabilities. This demand-side perspective strongly argues for the urgency of advancing multidisciplinary education. However, these studies primarily advocate for change at the level of principles. The operational core question of “how to systematically reconstruct the training system” still requires an integrated framework to provide a practical solution.

2.3 Limitations of Existing Shipping Talent Development Models

In response to new talent demands that is driven by structural transformation in the shipping sector, the existing mainstream talent development model presents systemic limitations in adaptability. The major issue lies in the deep contradiction between the traditional discipline-centered, theory-oriented framework and the goal of cultivating multidisciplinary, integrated talents. Specifically, these limitations are evident in three key areas.

Firstly, in knowledge system construction, disciplinary barriers remain rigid. University curricula largely deepen vertically within single disciplines like navigation or logistics, lacking effective mechanisms for interdisciplinary integration ^[15]. As a result, students struggle to develop the systematic knowledge frameworks required for advanced operations like shipping finance, maritime arbitration, and digital governance. This education system places excessive emphasis on academic grades while neglecting the development of comprehensive competencies, leaving students unable to integrate knowledge across disciplines to solve complex business challenges ^[16].

Secondly, in terms of competency development, the tendency to “prioritize theory over practice” continue to persist. Traditional classroom instruction remains dominant, lacking sufficient project-based learning, case studies, and industry-academia collaboration ^[17]. Neglecting practical skills hinders students’ ability to translate theoretical knowledge into real-world problem-solving capabilities ^[10]. This disconnects between training methods and the goal of cultivating comprehensive, practice-oriented competencies leaves graduates unprepared for actual shipping disputes, technological applications, or risk management scenarios.

Finally, in terms of responsiveness, talent development remains slow and poorly aligned with industry demands. Curriculum content and teaching objectives in higher education institutions update slowly, failing to incorporate cutting-edge topics such as artificial intelligence, green regulations, and geopolitical risks in a timely manner ^[7]. At the same time, a widespread phenomenon of “working in isolation” persists between universities and enterprises. University training programs are misaligned with real industry needs, while enterprises struggle to effectively empower talent through on-the-job training due to the lack of high-level training systems ^[15].

As a result, the existing model shows structural deficiencies across knowledge frameworks, competency development, and responsiveness. Minor adjustments are insufficient to address these issues. Only through systemic reconstruction—establishing a new model characterized by breaking disciplinary barriers, deepening industry-education integration, and possessing dynamic responsiveness—can the vast gap between talent supply and industry demand be effectively addressed.

2.4 Research Gaps

Existing research demonstrates that scholars have increasingly recognized the shipping industry’s shift from “hardware scale” to “hardware-software synergy”. There is a widespread acknowledgment that multidisciplinary integration is essential for cultivating high-end, composite shipping service professionals. However, a critical research gap persists. Most existing studies remain at the level of problem identification, emphasizing the necessity of reform, or offering general recommendations. What is still lacking is a detailed elaboration on a holistic framework design and implementation pathway for constructing an operational, systematically implementable talent development model that organically integrates multidisciplinary knowledge such as shipping, management, finance, law, and information. This study aims to bridge this gap. The following sections will first conduct an in-depth analysis of the specific challenges confronting current training models. Subsequently, it will propose and elaborate on a novel, systematic multidisciplinary talent development model to address the core issues repeatedly highlighted but not yet effectively addressed in existing literature.

3. Real-World Challenges in Cultivating High-End Shipping Service Talent

The global shipping industry is undergoing unprecedented transformation, with the digital technology revolution, geopolitical realignment, and green low-carbon transition. These shifts impose new and complex demands on the training model for

high-end shipping service professionals. Traditional discipline-centered training systems have become disconnected from industry demands. This chapter analyzes the current predicaments in cultivating high-end shipping service talent from four dimensions, namely: digital technology integration; geopolitical response; green and low-carbon transition; and university-enterprise collaboration mechanisms, revealing the practical obstacles to advancing multidisciplinary integration.

3.1 Challenges in Digital Technology Integration: Knowledge Gaps and Lack of Interdisciplinary Mechanisms

In the post-pandemic era, the rapid advancement of digital technologies presents an urgent challenge to talent development. The core contradiction lies in the industry's digital transformation demanding rapid knowledge iteration from professionals, while existing training systems lag significantly in both knowledge updating and interdisciplinary integration.

Primarily, knowledge gaps and skill divides continue to expand. Technologies like artificial intelligence, big data, and blockchain have become deeply embedded in high-end service scenarios such as ship energy efficiency management, intelligent scheduling, and supply chain finance. However, in maritime academy curricula, cutting-edge modules like smart ship operations and maintenance, and digital navigation systems account for less than 18% ^[11]. The curriculum remains centered on traditional maritime technologies and shipping management, failing to systematically incorporate cutting-edge digital technologies into required courses. This creates significant gaps in students' knowledge frameworks, leaving them ill-prepared for practical tasks involving intelligent systems and data analysis. Research on Nordic shipping enterprises confirms that a key bottleneck in the industry's digital and service-oriented transformation is the imbalance in talent structure ^[18]. A large proportion of industry employees possess traditional vessel operation experience but lack digital skills, while external digital talent often lacks understanding of the shipping sector's unique characteristics. Consequently, cultivating and attracting hybrid professionals proficient in both vessel operations and digital technology is recognized as a critical requirement for driving the industry's sustainable development. Moreover, shipping professionals will transition from traditional roles as vessel operators and maintainers to becoming observers of intelligent systems, initial processors of data information, integrators of cross-disciplinary knowledge, and practitioners of human-machine collaboration ^[19]. A significant skills gap has emerged between educational offerings and these evolving demands.

Furthermore, implementing interdisciplinary training faces multiple systemic barriers. Effective integration requires collaboration across fields such as shipping, information technology and law, yet these domains widely differ in their knowledge systems, curriculum structures, and faculty backgrounds, lacking effective cross-disciplinary integration mechanisms and shared platforms ^[7]. Additionally, there is a severe shortage of "dual-qualified" instructors proficient in both shipping operations and digital technologies. Incentive mechanisms, evaluation standards, and benefit distribution systems for cross-departmental collaborative education remain underdeveloped ^[20]. These systematic barriers make it difficult for students to build a comprehensive "shipping + digital" knowledge structure within the limited duration of their academic programs.

At a deeper level, entrenched talent paradigms pose a major challenge to digital skill adoption. When integrating digital technologies, the shipping industry faces not only hard constraints of knowledge and mechanisms but also soft constraints from traditional talent perceptions. Enterprises cling to talent philosophies rooted in "giftedness theory" and "exclusion of the exceptional," severely impedes organizational learning and the dissemination of new skills rendering even the most advanced management systems or technical training ineffective ^[21]. Therefore, industry-education integration must go beyond technical knowledge transfer to jointly build a learning ecosystem that encourages continuous growth and embraces trial-and-error, thus removing cultural barriers to the development of versatile talent.

3.2 Challenges from Geopolitical Shifts: Weak Risk Response and Rule Awareness

Geopolitics has evolved from a macro backdrop into a critical factor directly impacting shipping operations. Events like the Russia-Ukraine conflict and the Red Sea crisis have triggered route diversions, spikes in freight and insurance costs, exposing the global shipping system's extreme vulnerability. Traditional education models, heavily focused on technical and operational skills, prove inadequate in addressing such complex international risks.

On one hand, heightened shipping security risks have exposed inadequate training in crisis decision-making. Geopolitical conflicts continuously disrupt maritime market structures and security through mechanisms like economic sanctions, military

standoffs, and terrorism^[22]. High-end shipping service professionals must transcend purely technical perspectives, acquiring capabilities in international political-economic analysis, geo-risk identification, and rapid crisis decision-making. However, existing curricula severely lack content on international relations, geopolitics, and crisis management. This leaves students poorly equipped to maintain shipping continuity and security through strategic adaptability when confronting extreme scenarios such as supply chain disruptions or route blockades. On the other hand, awareness of global shipping governance rules remains weak. As global shipping governance system is increasingly politicized, shipping alliances evolve into political-economic communities where commercial logic intertwines with national interests^[23]. This necessitates professionals with deep understanding of international rules, cross-cultural negotiation skills, and policy judgment to participate in the new round of rule-making. However, existing training models insufficiently address these requirements, limiting students' ability to contribute to national participation in global shipping governance. To navigate complex geopolitical shifts, future training models must systematically integrate modules on international rules, geopolitics, and crisis management into curricula, focusing on cultivating students' strategic thinking and macro-level adaptability.

3.3 Challenges of Green and Low-Carbon Transition: Dual Shortcomings in Technical Knowledge and Governance Capabilities

The International Maritime Organization's (IMO) emissions reduction strategy and the global climate agenda are propelling the shipping industry toward a green and low-carbon future. This represents not only a technological revolution but also a restructuring of governance systems and economic logic, imposing new demands on the knowledge and capabilities of professionals. Previous research on major shipping countries shows that leading green shipping practices integrate vessel design, fuel selection, port operations, and national policies into a complex ecosystem, requiring talent with broad interdisciplinary integration capabilities^[24].

There are significant gaps in green technology literacy. Achieving the IMO's 2050 emissions reduction targets requires expanding new technologies including clean fuels such as: LNG, methanol, hydrogen; energy-efficient vessel designs; and carbon capture. High-end shipping service professionals must understand the fundamental principles, application scenarios, and economic viability of these green technologies while mastering international standards such as the Energy Efficiency Design Index (EEDI) and Carbon Intensity Indicator (CII). However, traditional curricula centered on shipping economics and management exhibit substantial gaps in this area, leaving students with limited understanding of core technologies driving the industry's green transformation. Also, sustainable governance capabilities have become more essential. The green transition has introduced carbon trading, green finance, and ESG (Environmental, Social, and Governance) standards, shifting the industry's economic logic from profit-centric to sustainable value creation. Consequently, future professionals must develop competencies in green financial product design, ESG assessment, and sustainable operational decision-making^[25]. This necessitates educational systems integrating engineering, economics, and management disciplines to offer new interdisciplinary modules such as "Green Shipping Management" and "ESG and Shipping Finance," thereby addressing students' current gaps in sustainable governance.

3.4 Challenges in Industry-Academia Collaboration: Weak Practical Training and Lack of Feedback Mechanisms

Industry-education integration is essential for nurturing multidisciplinary talent. However, current university-industry collaboration still suffers from deep-seated issues of "working in isolation," resulting in inadequate development of students' innovative practical skills. The fundamental barriers to digital transformation in the shipping industry stems more from structural challenges such as conservative organizational cultures, employee resistance to change, rigid departmental silos, and a shortage of digital talent^[26]. These internal industry challenges further reflect a broader disconnect between universities and enterprises in talent development.

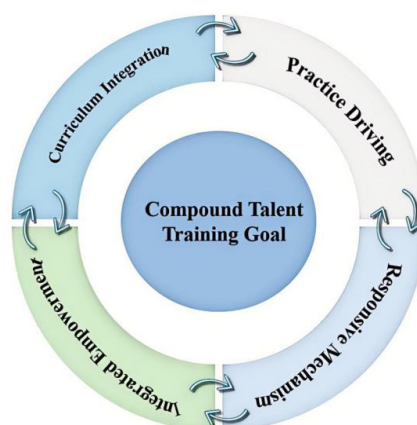
Practical training components often become mere formalities and severely disconnected from the real-world scenarios of high-end shipping services. Although universities commonly offer introductory internships and production placements, their content is frequently limited to basic operations. Internship positions offered by enterprises fail to engage students in high-value-added business processes such as shipping financial product design, maritime arbitration case handling, or digital

platform development^[17]. As a result, students have very limited opportunities to develop multidisciplinary competencies in authentic industry settings. Thus, the “theory over practice” bias. Additionally, the lack of engineering practice background among faculty constitutes a core obstacle to deepening practical teaching. Instructors are required to possess extensive industry experience to guide students in solving complex engineering and practical problems. However, there is a severe shortage of “dual-qualified” instructors proficient in both shipping operations and digital technologies especially in the engineering field. The maritime education faculty should not only impart theoretical knowledge but also possess substantial engineering practice experience to cultivate students’ practical abilities and comprehensive competencies^[27]. Yet, heavy teaching workloads and underdeveloped incentive structures tend to discourage faculty from gaining industry experience. This hinders their ability to fully leverage their critical role in guiding students’ practical innovation. Consequently, even well-designed practical components often yield limited results. The deeper issue lies in the lack of a two-way feedback mechanism between universities and industries. Academic curricula and course content slowly update and do not incorporate emerging challenges encountered by enterprises during their green and intelligent transformations. Simultaneously, businesses lack effective channels to communicate new skill requirements back to the university for enhanced curriculum design^[15]. The absence of this two-way feedback mechanism is one of the critical causes of the structural mismatch between talent supply and industry demand. Furthermore, corporate recruitment practices that prioritize narrow operational skills over interdisciplinary and innovation capabilities further weaken students’ motivation to engage in deep practical learning. As observed in the shipbuilding sector, shipping companies rarely consider students’ technological innovation achievements as hiring criteria, resulting to student disengagement from innovation activities^[27]. This same logic applies in the high-end shipping sector: if corporate recruitment continues to prioritize singular operational skills over interdisciplinary knowledge integration and innovative competencies, university-built practical training systems will struggle to gain students’ full attention and participation.

4. Establishing a Multidisciplinary Talent Development Model for High-End Shipping Services

Previous analysis indicates that traditional single-discipline training models exhibit structural deficiencies in knowledge frameworks, competency development, and response mechanisms, rendering them insufficiently equipped to address the complex challenges posed by digital convergence, geopolitics, and green transformation. To bridge the gap between talent supply and demand, this chapter proposes a C-P-R-I training model (as shown in Figure2) centered on four core features: Curriculum Integration, Practice Driving, Responsive Mechanism, and Integrated Empowerment. This model aims to systematically address the aforementioned challenges and provide a feasible way for effectively supplying high-end shipping professionals.

Figure2 C-P-R-I Training

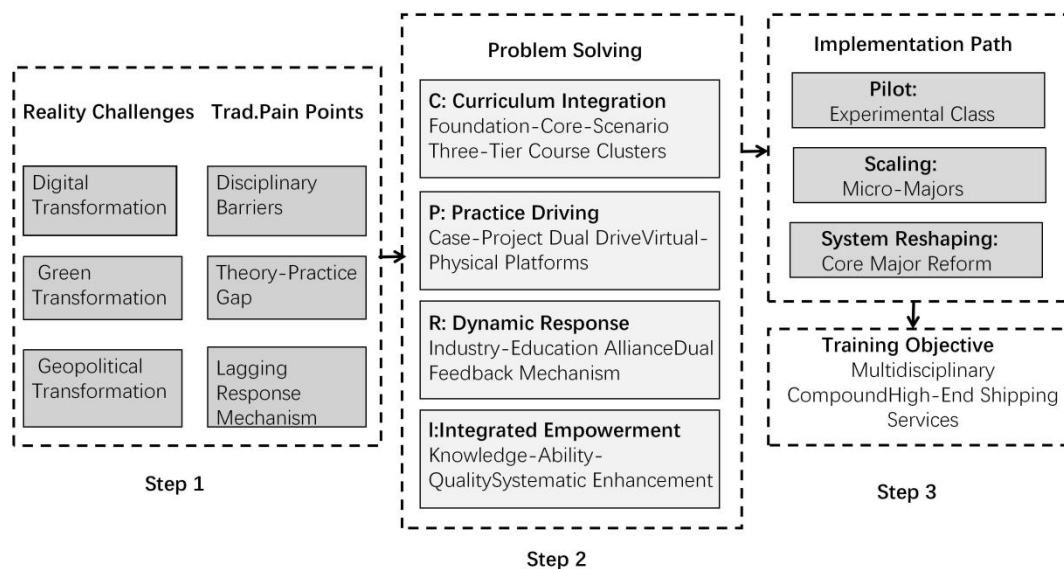


4.1 Overall Framework of the C-P-R-I Model

The proposed C-P-R-I model constitutes an integrated system centered on defined learning objectives, comprising four interconnected and mutually supportive subsystems. Its core aim is to transcend disciplinary boundaries and enhance

professional competencies. “Curriculum Integration (C)” serves as the knowledge foundation, breaking down barriers between shipping, management, finance, law, and information disciplines to reconstruct students’ knowledge frameworks. “Practice Driving (P)” serves as the competency engine, transforming knowledge into real-world problem-solving skills through dual-track “case-project” initiatives and “virtual-physical integration” platforms. “Responsive Mechanism(R)” functions as the regulatory hub, ensuring curriculum alignment with industry frontiers by building an agile ecosystem of industry-education integration. Ultimately, the synergistic interaction of these three elements collectively achieves “Integrated Empowerment (I)” enhancing students’ comprehensive competencies, and preparing them to lead the future development of the shipping industry. This framework fundamentally moves beyond the linear thinking of traditional models, emphasizing nonlinear interactions among elements and holistic effectiveness (as shown in Figure3).

Figure3: Overall Framework of the C-P-R-I Model



4.2 Curriculum Integration (C)

To address these gaps, the model implements a three-tiered “Foundation-Core-Scenario” curriculum cluster as shown in Table1 below. This structure is designed to systematically develop the knowledge frameworks that students require to navigate complex and uncertain industry landscapes.

Table1: Curriculum Architecture

Curriculum Tier	Curriculum Module	Example Course Name	Competency Objectives
Foundational Course Tier	Mathematics, Physics, and Economics/Management Foundations	Fundamentals of Economics/Finance, Operations Research and Statistics, Fundamentals of Green Shipping, Big Data and AI in Shipping, Digital Twin	Solidify Foundations in Mathematics, Economics/Management, and Green Shipping
Core Curriculum Layer	Management	Route and Schedule Optimization, Shipping Brokerage	Enhancing Shipping Operations and Management Capabilities
	Finance	Maritime Finance, Ship Financing, Marine Insurance	Mastering Shipping Finance and Risk Management Skills
	Technical	Green Shipping and Low-Carbon Technologies, Energy Efficiency Management	Acquire green technology and energy efficiency analysis capabilities
Scenario Integration Layer	Cases and Projects	“IMO 2050 Emissions Reduction Strategy,” “Red Sea Crisis Route Optimization,” “Blockchain Applications in Shipping Finance”	Enhancing judgment in complex scenarios and cross-disciplinary problem-solving capabilities

At the foundational course level, the model prioritizes strengthening students' competencies in mathematics, economic, management, and green shipping. Courses such as Economic and Financial Foundations, Operations Research and Statistics, Green Shipping Fundamentals, Shipping Big Data and AI, and Digital Twins are structured to provide a solid knowledge base for advanced studies.

At the core curriculum level, students deepen their specialized competencies through track-oriented modules. Management courses such as Route and Schedule Optimization and Shipping Brokerage; the finance courses offer Shipping Finance, Shipping Finance Practice, Marine Insurance, and Ship Financing; while technical courses focus on Green Shipping and Low-Carbon Technologies and Energy Efficiency Management.

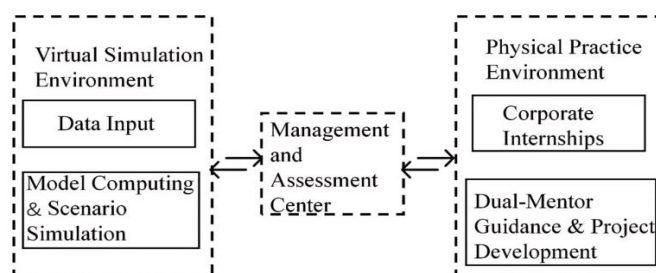
At the scenario-based level, teaching dynamically integrates cutting-edge industry challenges through case studies, workshops, and real-world project collaborations. For instance, in exploring intelligent shipping technologies, students examine real-world challenges like the limitations of AIS data and multi-source heterogeneous data integration, alongside blockchain applications in shipping supply chain finance and transparency enhancement, directly engaging with data security and technological innovation hurdles. In green governance modules, analytical frameworks are designed around implementation challenges and policy drivers for IMO emission reduction strategies and shore power technology as core green port initiatives ^[4].

The entire curriculum follows our-stage progressive path. In the first year, students compete foundational liberal arts courses in engineering, economics science, management and mathematics. The second year focuses on core shipping courses that build essential capabilities in operations research, data science, economics, management and regulatory frameworks. In the third year, students select one of the five specialized tracks, that is: Maritime Finance, Maritime Economics, Maritime Operations Management, Port Operations Management or Maritime Research Consulting, and also undertake advanced courses alongside intensive industry immersion. The final year centers on capability expansion, where the students work under joint university-enterprise supervision to apply multidisciplinary knowledge in cross-functional team projects and graduation thesis or designs, thereby transitioning from disciplinary learners to versatile problem solvers.

4.3 Practice Driving (P)

To address challenges in university-industry collaboration and the imbalance between theory and practice, this model centers practical application as the core competency development thread. It employs a dual-track case-project hybrid teaching reform throughout the entire process of cultivating high-end shipping service talent. The core objective is to enable students to transform multidisciplinary knowledge into professional competencies for solving systemic problems within complex scenarios that closely mirror real-world conditions. Case-based teaching focuses on developing judgment in complex scenarios, featuring real-world dilemmas such as “Fleet Renewal Strategies for IMO 2050 Emissions Targets” and “Route Optimization and Supply Chain Resilience Management Amid the Red Sea Crisis.” This approach guides students to dissect intricate interconnections between technology, economics, policy, and geopolitics. Project-based learning emphasizes action and creation. Students undertake comprehensive tasks like “Designing Green Shipping Transition Roadmaps” or “Developing Prototypes for Digital Maritime Evidence Platforms,” completing the entire process from technical feasibility analysis and business model construction to compliance reviews. This enhances their collaborative innovation and cross-domain problem-solving capabilities. To support this academic reform, the model concurrently builds a “virtual-physical integrated” practice platform, with its operational framework. (see Figure4)

Figure4: Operational Framework of the Practical Platform



At the physical level, project-based internship bases are established in collaboration with leading shipping enterprises, institutionalizing a “dual-mentor system” to ensure students engage deeply in high-value-added operations like shipping financial product design and digital platform development, rather than merely performing routine tasks. Simultaneously, faculty members are actively encouraged to pursue industry-academia-research collaborations within enterprises, feeding cutting-edge practices back into teaching to alleviate the bottleneck of dual-qualified instructors.

At the virtual level, a shipping management simulation system based on digital twin technology has been developed. This system simulates dynamic scenarios such as carbon quota trading, port congestion, and route disruptions caused by geopolitical conflicts. Within this secure “digital sandbox,” students practice replacing intuition-driven decisions with data-informed approaches, thereby strengthening their market sensitivity, risk prevention capabilities and resource optimization skills^[28]. This environment enables repeated trial-and-error and strategy refinement with zero operational risk, effectively enhancing students’ strategic decision making and risk management competencies.

Complementing this, the evaluation system for this model will shift from summative knowledge assessments to formative evaluations of process-based outcomes. Student project reports, case analyses, simulated negotiation performances, and decision-making logic within simulation systems will become key metrics for assessing their knowledge integration, innovative thinking, and practical application abilities, thereby comprehensively and objectively reflecting their competency development trajectories.

4.4 Responsive Mechanism (R)

The persistent lag and disconnect between talent cultivation and industry demands represent a critical weakness in traditional models. This model elevates dynamic responsiveness to a strategic level, committed to building a self-evolving, agile training ecosystem. Its cornerstone is the establishment of a “High-End Shipping Service Talent Cultivation Alliance” involving universities, shipping enterprises, financial institutions, law firms, government departments, and industry associations. This alliance serves not as a symbolic forum but as a substantive governance entity responsible for jointly developing training standards, reviewing curriculum content, and co-developing teaching resources. Its core function is to establish an institutionalized, two-way feedback and knowledge circulation mechanism.

On one hand, the alliance ensures continuous infusion of industry knowledge into education, where corporate experts serve not only as guest lecturers but as co-developers of curricula. The latest industry challenges and technological trends are swiftly transformed into teaching cases or updated course modules through the alliance mechanism. On the other hand, it strengthens the outward flow of academic knowledge into industry. University faculty members gain practical experience and research inspiration through the alliance, while their research outcomes provide decision-making support for enterprises. More importantly, the alliance has established a data-driven quality monitoring system. Through regular graduate career tracking, employer satisfaction surveys, and industry talent demand analysis, it generates assessment reports that serve as objective grounds for dynamically adjusting training programs (e.g., bi-annual fine-tuning). This mechanism ensures that the entire training model resonates with the rapidly evolving shipping industry, providing it with the vitality for continuous self-optimization.

4.5 Integrated Empowerment (I)

The coordinated operation of the Curriculum (C), Practice (P), and Responsive (R) subsystems ultimately converges on the value of Integrated Empowerment (I) for students. This concept emphasizes that the model aims not simply the accumulation of knowledge, but rather to systematically cultivate students’ ability to integrate multidisciplinary knowledge to solve systemic problems, make effective decisions in complex and uncertain environments, and develop the innovative thinking and leadership required to drive industry transformation. This is achieved through a convergent curriculum system, authentic practice-driven learning, and an agile response ecosystem. Together, they form a comprehensive implementation structure designed to nurture versatile, forward-looking professional for the future of high-end shipping services. The three major implementation phases and their corresponding core tasks are summarized in Table2 below.

Table2: Implementation Pathway and Phase Tasks

Implementation Phase	Core Tasks	Expected Outcomes
Pilot Exploration	Establish a “High-End Shipping Services Experimental Class” to validate the C-P-R-I full-cycle model	Develop replicable and scalable standardized training programs and management systems
Expansion and Promotion	Make mature modules available university-wide as “micro-majors” or minor degree programs	Break down disciplinary barriers to establish a new framework for interdisciplinary collaborative training
System Reengineering	Feed successful practices back into the core major training programs	Drive substantive enhancement and systematic restructuring across relevant university programs

In terms of implementation, a three-step strategy is recommended: “Pilot Exploration - Expansion and Promotion - System Restructuring.” The first stage involves establishing a “High-End Shipping Services Experimental Class” for comprehensive pilot validation. In the second stage, mature course modules should be made available to relevant majors in universities as “minor specializations” or “minor degrees”. Finally, successful experiences should be systematically integrated into the curriculum design of primary majors, driving in-depth reform and substantive enhancement across maritime, business, law, information, and other disciplines. In terms of safeguards, the key lies in deepening institutional coordination. Universities must fully recognize faculty contributions and achievements in interdisciplinary curriculum development, industry-academia collaboration, and case-based teaching within their internal evaluation and incentive systems. This approach breaks down departmental barriers and stimulates faculty’s intrinsic motivation to participate in model reform. Through the systematic operation of this entire C-P-R-I model, this framework ultimately enables the cultivation of multidisciplinary, composite talents tailored to high-end shipping service.

5. Conclusion

This study shows that the global shipping industry is undergoing profound transformation driven by digitalization, green initiatives, and geopolitical realignment. As a result, the core competitiveness of high-end shipping services has shifted from traditional asset scale to knowledge-intensive soft power. However, existing shipping talent development systems remain constrained by structural issues such as disciplinary silos, disconnect between theory and practice, and delayed responses to industrial changes, rendering them inadequate to support this transformation. To address these challenges, this paper proposes a multidisciplinary talent development model centered on Curriculum Integration (C) - Practice Driving (P) - Responsive Mechanism (R) - Integrated Empowerment (I).

This model breaks down disciplinary boundaries between shipping, finance, law, and information technology, reconstructing a three-tiered curriculum system (Foundation-Core-Scenario) that bridges knowledge gaps in digitalization and green governance. It enhances students’ professional competence in tackling complex engineering and management challenges through a dual-drive teaching approach (Case-Project) and a blended virtual-physical practice platform. Additionally, it establishes a dynamic, agile feedback system through an industry-education alliance to mitigate the lag between educational content and industrial development. Overall, this systematic approach offers a viable innovative pathway to address the mismatch between supply and demand for high-end shipping talent.

Although this study proposes a systematic training model, some limitations remain due to the scope of study and practical constraints, requiring further refinement in future work. The proposed C-P-R-I talent development model is innovative however; it is limited by its theoretical foundation and lack of large-scale empirical long-term tracking of pilot programs. Future research should conduct long-term tracking of pilot programs to assess graduates’ outcomes and verify the model’s effectiveness. Furthermore, the current methods for evaluating multidisciplinary integration skills rely more on qualitative assessment, therefore, a standardized quantitative assessment system should be developed. Finally, the success of the model depends on faculty development, and future work should explore institutional incentive mechanisms that support cross-disciplinary collaboration and cultivate dual-qualified instructors.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Research on Curriculum Ideological and Political Education in Higher Vocational Colleges Driven by Both New Infrastructure Empowerment and Integration of Production and Education

Yongfeng Li, Hu Sun*, Zhuyao Du, Rong Chen, Jia He

School of architecture and thermal engineering, Shaanxi Institute of Technology, Xian Shaanxi, 710300, China

*Corresponding author: Hu Sun, 632193711@qq.com

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Abstract: Against the dual backdrop of the in-depth advancement of the national new infrastructure strategy and the deepened development of industry-education integration in vocational education, curriculum ideological and political education in higher vocational colleges is confronted with practical challenges such as insufficient technical empowerment and lack of collaborative mechanisms. Taking the course Highway Construction Organization and Budget Estimation as the research carrier, this paper proposes a “three-dimensional integration” theoretical framework of “new infrastructure empowerment - industry-education integration - curriculum ideological and political education”, systematically analyzes the collaborative education mechanism of the three, explores the practical path of in-depth integration of “technology + ideological and political education + industry”, and constructs a dynamic and multi-dimensional evaluation system. Research shows that this model can effectively realize the organic unity of technical and skill imparting, professional quality cultivation and ideological and political value guidance, providing a replicable and promotable innovative paradigm for the high-quality development of curriculum ideological and political education in higher vocational colleges.

KeyWords: New Infrastructure; Industry-Education Integration; Curriculum Ideological and Political Education

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1. Research Background

At present, China is in a critical period of implementing the new infrastructure strategy, and new technologies such as intelligent construction and green transportation are accelerating the reshaping of the development pattern of the highway industry. This has put forward new requirements for the training of vocational transportation professionals, including “strong technology, comprehensive literacy, and firm value”. The 2020 Guiding Outline for the Construction of Ideological and Political Education in Higher Education Curriculum issued by the Ministry of Education clearly states that it is necessary to “make all types of courses and ideological and political courses go in the same direction and form a collaborative educational effect”^[1]. As the most closely related type of education to the industry, vocational education must base its curriculum ideological and political construction on the characteristic of “combining engineering and technology”, and achieve a deep integration of professional education and ideological and political education.

Emphasize that ideological and political education courses in vocational education should be based on professional characteristics, integrating professional spirit and craftsmanship into the curriculum system^[2]; From a theoretical and logical perspective, it is proposed that curriculum ideology should achieve a trinity of “knowledge imparting, ability cultivation, and value guidance”. In the field of engineering, some studies attempt to embed ideological and political elements such as professional ethics and integrity in courses such as preliminary budgeting and construction organization, but most of them are fragmented and lack systematic design. With the advancement of the new infrastructure strategy, the academic community has begun to pay attention to the impact of technological changes on vocational education. Under the background of new infrastructure, vocational education needs to accelerate its digital transformation and build a teaching model that integrates online and offline teaching^[3-4]; Taking civil engineering as an example, explore the integration path of intelligent construction technology and talent cultivation^[5-6]. However, existing research mostly focuses on the application level of technology and fails to organically combine the technological attributes of new infrastructure with the value attributes of ideological and political education^[7]. Overall, existing research has achieved certain results in a single dimension, but there are significant gaps in the synergy of new infrastructure, industry education integration, and curriculum ideology and politics^[8-9]. There are still problems in the current ideological and political practice of higher vocational courses, such as the disconnection between the application of new infrastructure technology and the exploration of ideological and political value, insufficient coordination between industry education integration practice and ideological and political education, and the mismatch between curriculum ideological and political evaluation and professional training objectives. In this context, exploring the curriculum ideological and political model under the dual drive of new infrastructure and industry education integration has become the key to solving the problem of vocational education.

2. Construction of the “Three Dimensional Fusion” Theoretical Framework

2.1 Theoretical Basis: Dual Support of Systems Theory and Synergy Theory

Systems theory holds that things are an organic whole composed of interconnected elements, and their function is greater than the sum of each element. Regard new infrastructure, integration of industry and education, and curriculum ideology and politics as three core elements, which are not simply stacked, but form a synergistic effect through the interaction between the elements. The collaborative theory further points out that the orderly interaction of internal elements in the system is the key to achieving overall optimization, which provides methodological guidance for the analysis of the mechanism of “three-dimensional fusion”.

In this dynamic system, each element not only maintains its independent core value but also serves as a catalyst to activate the potential of the other two components. New infrastructure, with its digital and intelligent features, breaks through the spatial and temporal limitations of industry-education integration and curriculum ideology and politics, enabling real-time resource sharing and collaborative innovation. Industry-education integration, in turn, provides a practical scenario for curriculum ideology and politics, making ideological guidance more down-to-earth and targeted. Meanwhile, curriculum ideology and politics endows the development of new infrastructure and industry-education integration with a value core, ensuring that all collaborative practices move forward in the direction of cultivating high-quality talents with both moral integrity and professional ability. This mutually reinforcing relationship is exactly the embodiment of synergy theory in practical application, laying a solid theoretical foundation for the efficient operation of the three-dimensional fusion mechanism.

2.2 The core connotation and interactive logic of “three-dimensional fusion”

The three-dimensional integration theoretical framework of “New Infrastructure Empowerment - Industry Education Integration - Curriculum Ideology and Politics” includes three core dimensions: the first is the technology empowerment dimension, which uses new infrastructure technologies such as intelligent construction organization and low-carbon cost management as carriers to explore ideological and political elements such as national strategy, innovation spirit, and ecological concept; The second dimension is collaborative education, which transforms the professional ethics and craftsmanship spirit of enterprises into ideological and political education resources through the integration of industry and education models such as school enterprise dual main sports personnel and modern apprenticeship system; The third is the dimension of value guidance, constructing a three in one educational goal of “technical skills professional ethics ideological

and political values”, and achieving resonance between knowledge imparting and value guidance.

The interactive logic of the three is manifested as follows: new infrastructure technology provides a digital and intelligent practical carrier for the integration of industry and education, industry education integration injects industry practice genes into curriculum ideology, and curriculum ideology endows the application of new infrastructure technology and the integration of industry and education with value soul, forming a closed-loop education system of “technical support industry collaboration value guidance”.

3.The practical path of ideological and political education in the “three-dimensional integration” course

3.1 Teaching Content Reconstruction: Exploring Ideological and Political Elements in New Infrastructure Scenarios

Based on the course of “Highway Construction Organization and Preliminary Budget” as the core, reconstruct the teaching content according to the logic of “professional knowledge+ideological and political elements+industry demand”. In the “Construction Schedule Planning” module, combining BIM+GIS intelligent schedule management technology, integrating the analysis of the “Transportation Power” strategy and the cultivation of teamwork spirit; In the “Engineering Cost Estimation” module, focusing on the pricing of green and low-carbon materials, incorporating the concept of sustainable development and ecological responsibility education; In the “Construction Scheme Comparison” module, through the analysis of smart high-speed construction cases, students’ awareness of technological innovation and the quality of overcoming difficulties are cultivated. By establishing a mapping table of “professional knowledge points ideological and political elements industrial needs”, the organic connection between ideological and political content and professional teaching can be achieved^[10]. When explaining the construction organization of prefabricated bridges, not only are technical points such as component prefabrication and hoisting introduced, but also super engineering cases such as the Hong Kong Zhuhai Macao Bridge are combined to explain the scientific research spirit and national engineering strength behind the “Great Nation Heavy Machinery”, so that students can enhance their national pride in technical learning.

3.2 Development of Teaching Resources: Building an Intelligent Resource Ecology for School Enterprise Collaboration

Teaching resources are the key carrier for the implementation of the “three-dimensional integration” model. Adopting the model of “school enterprise data sharing, technology co research, and resource co construction”, jointly developing a digital resource library of “new infrastructure+curriculum ideological and political education” with industry enterprises. The resource library consists of three major modules: firstly, a typical engineering case library, which includes cases of new infrastructure projects such as smart highways and low-carbon highways. Each case has three sub columns: “Technical Analysis”, “Ideological and Political Highlights”, and “Industry Connection”, which not only explain the technical principles of intelligent monitoring systems, but also extract the craftsmanship spirit of “striving for excellence and pursuing excellence”; The second is the virtual simulation project library, which uses VR technology to restore scenes such as tunnel construction and roadbed cost. Students can master the technical points through immersive operations, and receive responsibility education in the “construction safety accident simulation” section; The third is the ideological and political micro course video library, which collects a series of micro courses recorded by enterprise technical experts and industry model workers, showcasing their professional insights and value pursuits in frontline work.

3.3 Construction of Teaching Staff: Building a “Dual Teacher and Dual Ability” Ideological and Political Education Team

The teaching staff is the core force in implementing the “three-dimensional integration” model. Build a three in one teaching team consisting of on campus teachers, enterprise mentors, and ideological and political experts, and enhance the team’s ideological and political education capabilities through “special training, mutual recruitment between schools and enterprises, and joint teaching and research”. One is to empower teachers through specialized training, regularly organizing them to participate in specialized training on topics such as “Integration of New Infrastructure Technology and Curriculum Ideology and Politics” and “Integration of Industry and Education Education Mechanism”. The second is mutual employment and

exchange between schools and enterprises, arranging teachers on campus to work in enterprises for training, participating in real engineering project construction, understanding the latest technology and ideological and political education needs of the industry, and hiring senior engineers from enterprises as part-time teachers to undertake practical teaching and ideological and political case explanation tasks.

3.4 Innovation of Teaching Mode: Building a Blended Teaching System with School Enterprise Collaboration

Adopting a blended learning model of “online self-learning+offline practice deepening+enterprise field research”. Online, relying on the digital resource library jointly built by schools and enterprises, students complete tasks such as “virtual simulation operation+ideological and political micro course learning+case analysis and discussion” through the online platform. Teachers track learning data through the platform and assign personalized assignments accordingly; Offline teaching is divided into “theoretical lectures+project training”. In theoretical courses, “problem oriented+case teaching” is used to guide students to think about the concept of green development through the question of “how to reduce carbon emissions from highway construction”; Implement “project driven teaching” in practical training courses, divide students into groups of 6-8 people, and use real enterprise projects as task carriers to complete the entire process from construction organization design to cost preparation. Teachers and enterprise mentors work together to guide and integrate professional ethics education such as teamwork and cost control into project implementation.

3.5 Optimization of Evaluation System: Establishing a Dynamic and Multidimensional Evaluation Mechanism

Construct a “three-dimensional twelve index” evaluation system from three dimensions: technical skills, professional ethics, and ideological and political values. Setting indicators such as intelligent cost software operation and construction plan design in the dimension of technical skills; The dimension of professional ethics includes indicators such as team collaboration and sense of responsibility; The dimensions of ideological and political values include indicators such as patriotism and green concepts. The Analytic Hierarchy Process is used to determine the weights of indicators, with technical skills accounting for 40%, professional ethics accounting for 35%, and ideological and political values accounting for 25%. Introduce a diversified evaluation subject of “student self-evaluation peer evaluation teacher evaluation enterprise evaluation”, combined with process evaluation (classroom performance, project practice records) and outcome evaluation (assessment scores, enterprise feedback), to achieve dynamic and accurate evaluation process. Develop a “Course Ideological and Political Evaluation Management System” to automatically collect student learning data, generate “Personal Growth Reports” and “Class Overall Analysis Reports”, and provide data support for teaching improvement. In the assessment of the “Highway Engineering Cost Compilation” project, not only is the accuracy of students’ cost results (technical skills) evaluated, but their innovative consciousness (professional ethics) is also evaluated through the “Cost Optimization Suggestions” in the project report, and their ecological concept (ideological and political value) is evaluated through the “Green Material Selection Instructions”.

3.5.1 Teaching Content Reconstruction: Exploring Ideological and Political Elements in New Infrastructure Scenarios

Based on the course of “Highway Construction Organization and Preliminary Budget” as the core, reconstruct the teaching content according to the logic of “professional knowledge+ideological and political elements+industry demand”. In the “Construction Schedule Planning” module, combining BIM+GIS intelligent schedule management technology, integrating the analysis of the “Transportation Power” strategy and the cultivation of teamwork spirit; In the “Engineering Cost Estimation” module, focusing on the pricing of green and low-carbon materials, incorporating the concept of sustainable development and ecological responsibility education; In the “Construction Scheme Comparison” module, through the analysis of smart high-speed construction cases, students’ awareness of technological innovation and the quality of overcoming difficulties are cultivated. By establishing a mapping table of “professional knowledge points ideological and political elements industrial needs”, the organic connection between ideological and political content and professional teaching can be achieved.

3.5.2 Innovation of Teaching Mode: Building a Blended Teaching System with School Enterprise Collaboration

Adopting a blended learning model of “online self-learning+offline practice deepening+enterprise field research”. Based

on the digital resource library jointly built by schools and enterprises online, develop virtual simulation projects to enable students to learn technology and gain insights into ideological and political education through simulating smart highway construction scenarios; Establish a joint teaching and research group composed of teachers and enterprise engineers offline, transform real enterprise projects into teaching cases, and integrate professional ethics education into the practical training process; Regularly organize students to study at leading enterprises in the industry, and through communication with frontline technical personnel, they can intuitively experience the spirit of craftsmanship and innovative culture.

3.5.3 Optimization of Evaluation System: Establishing a Dynamic and Multidimensional Evaluation Mechanism

Construct a “three-dimensional twelve index” evaluation system from three dimensions: technical skills, professional ethics, and ideological and political values. Setting indicators such as intelligent cost software operation and construction plan design in the dimension of technical skills; The dimension of professional ethics includes indicators such as team collaboration and sense of responsibility; The dimensions of ideological and political values include indicators such as patriotism and green concepts. The Analytic Hierarchy Process (AHP) is used to determine the weights of indicators, and a diversified evaluation subject of “student self-evaluation peer evaluation teacher evaluation enterprise evaluation” is introduced. Combined with process data (classroom performance, project practice records) and outcome data (skills competition results, enterprise feedback), the evaluation process is dynamic and accurate.

4. Practical achievements

Since January 2025, the teaching pilot program for civil engineering related majors in Shaanxi Defense Industry Vocational and Technical College for the class of 2025 has been carried out. Through a one-year practice, the “three-dimensional integration” model has achieved significant results, manifested as “three improvements and two breakthroughs”.

Significant improvement in students’ comprehensive abilities: Firstly, there has been a significant improvement in professional skills, with pilot class students winning 5 awards in the provincial vocational skills competition, an increase of 60% compared to the previous session. Secondly, there has been a significant improvement in professional ethics. Through feedback from internships in enterprises, students’ team collaboration, communication, and problem-solving abilities have been scored 10 points higher than the average score of non pilot classes. The overall satisfaction rate of graduates from enterprises has increased from 82% to 93%; The third is the deep internalization of ideological and political consciousness. A questionnaire survey shows that 87% of students have a deep understanding of the mission and responsibility of highway builders, and 92% of students believe that learning new infrastructure technologies enhances their patriotism. The number of students actively participating in social practice activities such as “green campus construction” and “rural road research” has increased compared to before the pilot.

Continuous breakthroughs in teaching reform achievements: Firstly, significant progress has been made in the construction of teaching resources, with a cumulative visit volume of 10000 to the digital resource library jointly built by schools and enterprises. Secondly, research and teaching achievements continue to emerge, with the team publishing 3 papers related to ideological and political education in courses and applying for 1 provincial-level teaching reform project. The third is to deepen the cooperation between schools and enterprises, and jointly establish a “Course Ideological and Political Training Base” with multiple companies, forming a good situation of “school enterprise collaboration, mutual benefit and win-win”.

5. Research prospects

Although the “three-dimensional integration” model has achieved certain results in practice, it still faces some challenges, such as the incomplete establishment of a long-term mechanism for school enterprise cooperation in education, and the need to improve the accuracy of intelligent evaluation tools. Future research can be deepened in the following four directions.

5.1 Expansion Mode Application Fields and Levels

On the one hand, the “three-dimensional integration” model will be promoted from the course of “Highway Construction Organization and Preliminary Budget” to other vocational civil engineering majors such as construction engineering technology, engineering cost, municipal engineering technology, etc., forming a “civil engineering professional course ideological and political cluster”; On the other hand, exploring cooperation with application-oriented undergraduate

colleges, building a “vocational college undergraduate” integrated curriculum ideological and political system, and achieving collaborative education at different educational levels. At the same time, we will attempt to apply the model to the field of vocational skills training, providing “technology+ideological and political” continuing education services for industry employees, and helping them improve their professional ethics.

5.2 Develop intelligent ideological and political evaluation tools

Collaborate with experts in the fields of computer science and educational technology to develop a “Course Ideological and Political Intelligent Evaluation System” using big data and artificial intelligence technology. By analyzing textual and behavioral data such as students’ classroom speeches, project reports, and practical performance, and using technologies such as natural language processing and sentiment analysis, automatic evaluation and dynamic tracking of the internalization effect of students’ ideological and political values can be achieved. Establish a ‘student ideological and political growth model’, develop personalized ideological and political education plans for each student, and enhance the accuracy and effectiveness of ideological and political education.

5.3 Building a long-term mechanism for school enterprise collaboration

Suggest that the government introduce more incentive policies and provide tax exemptions, credit points, and other benefits to enterprises participating in ideological and political education courses, in order to stimulate their intrinsic motivation to participate; The school and the enterprise signed a “Curriculum Ideological and Political Co construction Agreement”, clarifying the rights and obligations of both parties in resource development, teacher recruitment, teaching implementation, and establishing a cooperation mechanism of “benefit sharing and risk sharing”; Establish the “Industry Curriculum Ideological and Political Alliance”, unite various forces such as universities, enterprises, and industry associations to jointly develop standards for curriculum ideological and political construction, promote resource sharing and mutual recognition of achievements.

5.4 Deepen the integration and innovation of new infrastructure technology and ideological and political education

Track the application of cutting-edge new infrastructure technologies such as 5G, IoT, and digital twins in the highway industry, timely explore their ideological and political elements, systematic thinking in digital twin technology, and collaborative concepts in IoT technology. Explore the teaching mode of “metaverse+curriculum ideological and political education”, use metaverse technology to construct virtual highway construction scenes, allow students to experience the entire process of building a “transportation power” in a virtual environment, and enhance the immersion and attractiveness of ideological and political education. At the same time, studying the impact of new infrastructure technologies on professional ethics, such as the fairness of intelligent algorithms and the importance of data security, integrating them into ideological and political education courses, and cultivating students’ awareness of technological ethics.

6. Conclusion

Under the dual drive of new infrastructure empowerment and integration of industry and education, the ideological and political education of higher vocational courses is an innovative exploration of implementing the fundamental task of moral education and talent cultivation in vocational education in the new era. It is also an inevitable requirement for responding to industrial changes and cultivating high-quality technical and skilled talents. The “three-dimensional integration” model breaks the traditional situation of “two skins” between professional teaching and ideological and political education through the construction of theoretical frameworks, innovation of practical paths, and optimization of evaluation systems, achieving the organic unity of technology, industry, and ideological and political education. In practice, this model not only enhances students’ comprehensive abilities, but also promotes the deep development of teaching reform and school enterprise cooperation. In the future, it is necessary to further deepen the collaboration between schools and enterprises, strengthen technical support, improve guarantee mechanisms, and continue to explore the innovative path of “new infrastructure+integration of industry and education+curriculum ideology and politics”, so that curriculum ideology and politics can truly become the “soul project” of vocational education talent cultivation, cultivate more high-quality technical and skilled talents who combine morality and technology, and integrate knowledge and practice for the implementation

of national strategies and industrial upgrading, and contribute wisdom and strength to the high-quality development of vocational education.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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A Review of Research on Artificial Intelligence Writing Feedback: Mechanisms, Learner Behaviours, and Future Directions

Gufeng Wu^{1*}, Rosilawati Sueb¹, Qingyi Deng²

1.Faculty of Education, Puncak Alam Campus, Universiti Teknologi MARA (UiTM), 40450, Selangor, Malaysia

2.Faculty of Media and Art Design, Guangzhou Huali College, Guangdong, 511325, China

*Corresponding author: Gufeng Wu, wgf0829@gmail.com

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Abstract: This study systematically reviews the evolution of Artificial Intelligence (AI) writing feedback from Automated Writing Evaluation (AWE) to generative Large Language Models. Existing evidence indicates that AI enhances writing quality. However, research regarding the mechanisms through which feedback translates into concrete revision behaviours remains insufficient. Drawing upon Feedback Intervention Theory and Writing Process Theory, this paper analyses the distinctions between local linguistic feedback and global discourse feedback. It further explores critical variables including learner cognitive assessment, revision intention, and affective responses. A comprehensive conceptual framework is constructed. This framework elucidates the mediating role of feedback satisfaction in connecting technical characteristics with revision depth. Addressing current limitations in process data collection and short-term designs, the article calls for a shift towards longitudinal empirical paradigms combined with behavioural tracking. Ultimately, the study underscores the necessity of enhancing feedback literacy and establishing ethical norms within the context of human-machine synergy to achieve sustainable development in writing education.

Keywords: Artificial Intelligence Writing Feedback; Automated Writing Evaluation; Generative AI; Revision Behaviour; Feedback Satisfaction; Learner Engagement

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1.Introduction

1.1 Research Background and Importance

Over the past decade, the functionality of AI writing feedback tools has undergone a significant transformation, evolving from traditional Automated Writing Evaluation (AWE) systems, such as Criterion and Pigai, to Large Language Models (LLMs) represented by ChatGPT^[1]. Initially focused on grammatical error correction and surface-level linguistic monitoring, these tools are now capable of providing multi-layered suggestions regarding content development, discourse structure, logical organisation, and rhetorical strategies. Consequently, the utility of AI has expanded beyond the scope of an auxiliary proofreading tool^[2]. It is now increasingly conceptualised as an intelligent writing partner. A wealth of existing literature corroborates the efficacy of these technologies in diverse settings^[3]. This includes higher education and classrooms focused on English as a Foreign or Second Language. Both AWE systems and generative AI assistants have been proven to aid

students in refining linguistic accuracy. Furthermore, they support the development of textual organisation and elevate the overall quality of writing. Furthermore, their potential to facilitate learner attention to language, alleviate cognitive load, and reinforce process-oriented writing has garnered increasing empirical support^[4].

Notwithstanding these advancements, current research exhibits notable limitations that constrain a comprehensive understanding of the mechanisms underlying AI writing feedback. Primarily, studies remain heavily result-oriented, with a scarcity of evidence regarding behavioural processes. Most empirical inquiries utilise pre-test and post-test designs to ascertain improvements in writing quality, yet pay limited attention to how learners interpret feedback, the way they selectively adopt suggestions, and the cognitive and behavioural operations that occur during the actual revision process^[5]. Although existing research has revealed that feedback contributes to outcome improvement, explanations regarding how feedback is translated into writing enhancement through behavioural processes remain tenuous^[6].

Secondly, there is a prevalent lack of theoretical scaffolding. Reviews have highlighted that AWE research frequently lacks systematic elucidation based on feedback theory, learner engagement theory, or writing process theory. This results in studies that appear more as technical effect tests rather than responses to critical issues in educational and learning theories, particularly in explaining the mechanistic chain linking feedback quality, learner perception, and writing behaviour^[7]. Such deficiencies render many studies unable to explain ‘why’ feedback is effective or ineffective and impede the formation of a more cumulative body of knowledge.

Thirdly, the era of generative AI writing has introduced a new set of challenges. Distinct from traditional AWE systems, which primarily offer local and surface-level feedback, Large Language Models (LLMs) such as ChatGPT can generate deep-level feedback that includes explanations, examples, and even direct rewriting. While this capability significantly enhances the comprehensibility of feedback, it simultaneously triggers novel research concerns: whether high reliance on AI might diminish autonomous revision capabilities; whether generative feedback blurs the boundaries of authorship and originality; and how learner trust or scepticism towards AI feedback influences adoption behaviours. Furthermore, questions arise regarding the specific ‘feedback literacy’ learners require to utilise these tools effectively in such contexts^[8]. These issues extend beyond technical efficacy, touching upon profound challenges in cognitive, ethical, and educational policy domains.

Against this backdrop, a systematic review is essential to delineate the current landscape of AI writing feedback research from a holistic perspective. Although the volume of studies concerning Automated Writing Evaluation (AWE) and generative AI feedback has increased in recent years, a comprehensive framework capable of integrating technical features, learner psychological experiences, behavioural response mechanisms, and writing learning outcomes remains absent. Existing literature tends to focus on isolated dimensions—such as comparisons of feedback types (e.g., immediate vs. delayed; surface vs. deep), the direct impact of feedback on writing quality, or subjective perceptions of system usability—while failing to connect these elements into a cohesive causal chain. Consequently, it is imperative to scrutinise AI writing feedback research through the lens of ‘feedback characteristics—learner experience—behavioural response—writing outcome’ to drive theoretical deepening and practical optimisation.

1.2 Research Objectives

To address these needs, the present review seeks to achieve four objectives. First, it aims to systematically summarise core findings regarding current AI writing feedback (encompassing both traditional AWE systems and LLM-based generative AI), specifically focusing on major developments in feedback types, functional positioning, and pedagogical effects, thereby mapping the evolutionary path of feedback mechanisms under different technological paradigms. Second, adopting a dual perspective of learner behaviour and psychology, this review intends to explicate engagement patterns, cognitive processing, and characteristics of revision behaviour following the receipt of AI feedback. This includes an analysis of revision depth, adoption rates, emotional experiences, and trust in the tool, to reveal how AI feedback is utilised in authentic learning contexts. Third, building upon existing theories, a behavioural mechanism framework centred on feedback satisfaction is proposed. This framework elucidates how AI writing feedback influences learner value judgements, willingness to revise, and strategy selection, ultimately translating into observable revision behaviours that foster the development of writing competence. Finally, this paper identifies critical gaps in current research regarding methodology, application contexts, learner

individual differences, and feedback design, offering theoretical support and reference designs for future empirical inquiries to promote the systematisation and profundity of AI writing feedback research.

2. Theoretical Foundations

2.1 Feedback Intervention Theory and Feedback Functions

Feedback Intervention Theory (FIT)^[9] provides a critical perspective for comprehending the effects of feedback. The theory posits that the efficacy of feedback is contingent upon the level at which learner attention is directed, encompassing the task, process, self-regulation, and self-levels. Performance enhancement is effectively promoted when feedback concentrates on the task itself (e.g., error identification, problem explanation) and associated processes (e.g., ideation strategies, logical organisation). Conversely, feedback emphasising individual self-evaluation or capability judgement may instigate negative self-attention, thereby diminishing learning motivation and performance quality. In the context of AI writing feedback, contemporary mainstream systems (such as AWE or generative AI) typically deliver substantial information at the task and process levels. This includes linguistic error annotation, expression paraphrasing suggestions, textual organisation prompts, and logical coherence analysis, thus theoretically possessing high pedagogical potential^[10]. However, given the capacity of AI to present large-scale, dense, and multi-dimensional feedback, the information density often exceeds that of human teacher feedback. This disparity may compel learners to process a vast quantity of suggestions within a short timeframe, creating risks associated with increased cognitive load, attention dispersion, or ‘feedback fatigue’. Consequently, achieving an equilibrium between providing sufficient information and maintaining manageability has emerged as a pivotal issue in technological design and pedagogical application.

Within the realm of educational assessment and instructional feedback, the classic feedback function framework proposed by Hattie and Timperley^[11] further deepens the understanding of effective feedback. They articulated three core questions from a learning-oriented perspective: ‘Where am I going?’, ‘How am I going?’, and ‘Where to next?’. This framework underscores that feedback should not merely identify issues but must also provide direction and strategies. Applying this framework to AI writing feedback facilitates an effective distinction between the feedback levels and functions of various systems. Certain systems are restricted to ‘problem identification’ (such as highlighting grammatical or spelling errors), which constitutes typical task-level feedback. In contrast, advanced systems (e.g., generative AI based on Large Language Models) can offer ‘revision strategies’ and ‘explanations of writing principles’, thereby addressing deeper questions regarding ‘how to modify’ (process level) and ‘why to modify in this manner’ (self-regulation level). Existing literature also indicates that feedback possessing explanatory, strategic, or model-demonstration characteristics is more likely to stimulate learner willingness to revise and facilitate deep learning^[12]. Therefore, basing analysis on the functional classification of Hattie and Timperley allows for a more systematic evaluation of the ‘information quality’ and ‘actionability’ of AI feedback, providing a theoretical foundation for subsequent behavioural mechanism models.

2.2 Writing Process Theory and Revision Behaviour

Process Writing Theory conceptualises writing as a dynamic and recursive cognitive sequence, encompassing distinct stages such as planning, translating, reviewing, and revising^[13]. Within this framework, revision behaviour is widely regarded as the central mechanism fostering the development of writing competence. This is because revision entails not only the correction of surface-level linguistic elements but also the profound reprocessing of content logic, discourse structure, and argumentation strategies^[14]. During the revision phase, writers are required to continuously compare the ‘goal text’ against the ‘current text’ and adjust based on identified discrepancies. Such a process intrinsically embodies self-monitoring and metacognitive regulation within the writing activity.

In the context of AI writing feedback applications, technological intervention is predominantly concentrated within the ‘reviewing revising’ stage. On the one hand, AI assists learners in identifying deficiencies at the linguistic, content, and structural levels through mechanisms such as grammatical annotation, error detection, and logical analysis, thereby enhancing their capacity for problem detection^[15]. On the other hand, generative AI can provide alternative expressions, sentence restructuring, paragraph reorganisation, and even exemplary texts. These features enable learners to acquire more explicit directions for revision alongside richer linguistic input. Furthermore, the immediate feedback provided by AI influences the

learners' level of self-assessment regarding text quality, which subsequently regulates their cognitive judgements concerning the necessity of revision.

Drawing upon Process Writing Theory, it is evidently insufficient to evaluate the efficacy of AI feedback solely based on the final scores of written products. Recent scholarship suggests that the impact mechanisms of AI writing feedback should be examined through procedural indicators^[16]. These include whether learners generate a revision intention, the depth of revision undertaken (surface versus deep), the specific revision strategies employed (such as substitution, deletion, expansion, or rewriting), and whether the revision behaviour reflects cognitive investment and reflective processing^[17]. These mediating process variables serve to unveil the pathways through which AI feedback functions in the development of learner writing, holding significant value for comprehending the genuine merit of technological intervention. In other words, the effectiveness of AI writing feedback depends not critically on 'what is said' by the system, but rather on 'what is done' by the learner and 'how it is executed'^[18].

2.3 Learner Engagement and Perspectives on Feedback Literacy

In recent years, the paradigm of feedback research has witnessed a marked transition: moving from a traditional emphasis on 'how teachers provide feedback' towards a focus on 'how students comprehend, utilise, and transform feedback'. This shift underscores the proactive agency of learners within the feedback process. Systemic reviews indicate that learner engagement with written corrective feedback can be delineated into behavioural, cognitive, and affective dimensions, which collectively determine whether feedback translates into tangible writing improvement^[19]. Behavioural engagement is manifested in revision frequency and depth; cognitive engagement involves the interpretation, judgement, and integration of feedback content; while affective engagement encompasses emotional factors such as trust, anxiety, and dependency, all of which directly influence the willingness to adopt feedback^[20].

Within the specific context of AI writing feedback, learner engagement exhibits more diversified patterns. A subset of learners demonstrates high dependency, tending to accept AI suggestions 'wholesale' without deep judgement regarding their validity. Conversely, other learners display greater agency, forming a mode of 'active regulatory engagement' by comparing multiple feedback sources, adopting suggestions selectively, and adjusting them in alignment with their own writing objectives^[21]. Concurrently, certain learners, driven by scepticism regarding AI credibility, reduce interaction frequency, utilising the system merely as an auxiliary tool for checking grammar or spelling^[7]. These disparities illustrate that AI writing feedback does not automatically yield learning effects; its potential to genuinely foster writing development is heavily contingent upon the quality of learner engagement^[22].

To explicate the disparities, the feedback literacy framework offers substantial theoretical support. This framework posits that learners require not only the ability to comprehend the feedback content itself but also the capacity to evaluate its quality, judge its applicability, and ultimately convert it into concrete revision actions^[23]. These three competencies have become particularly critical in the era of generative AI. Given that AI systems may produce inconsistencies, ambiguities, or even erroneous information, the judgement and regulatory capabilities of the learner directly dictate their ability to benefit from the technology. Consequently, enhancing learner feedback literacy—specifically the capacity for critical evaluation of AI feedback and self-regulation—has emerged as a core condition for promoting the pedagogical effectiveness of AI writing feedback.

3. Types and Characteristics of AI Writing Feedback

3.1 Local Linguistic Feedback

Local linguistic feedback primarily centres on surface-level linguistic forms, encompassing the normative aspects of grammar, spelling, punctuation, lexical collocation, and sentence structure. Historically, this category of feedback has been extensively utilised by Automated Writing Evaluation (AWE) systems, such as Criterion, Write Improve, and Pigai, characteristically relying on linguistic rule detection, statistical models, or machine learning algorithms to identify and annotate linguistic errors^[24]. A substantial body of research indicates that local linguistic feedback plays a significant role in enhancing learner linguistic accuracy. Particularly within the demographic of elementary and intermediate EFL/ESL learners, the provision of large-scale, immediate error correction effectively reduces syntactic errors and improves lexical

appropriateness and linguistic standardisation^[25]. Nevertheless, the scope of influence exerted by local linguistic feedback is typically confined to the surface level, offering limited promotion of higher-order writing competencies such as content development, discourse coherence, and logical organisation.

From the perspective of pedagogical application, local linguistic feedback presents multiple advantages. Firstly, given the capacity of systems to instantly generate a multitude of specific and actionable revision suggestions, learners can obtain clear error localisation and rewriting examples within a brief timeframe, which is conducive to forming rapid error awareness and correction cycles^[26]. Secondly, local feedback is generally presented through annotations, substitutions, or localised suggestions. These formats are capable of being reviewed repeatedly and are straightforward to manipulate, thereby requiring lower comprehension costs and alleviating cognitive load during the feedback processing stage^[27]. Furthermore, for learners with a weaker linguistic foundation, local feedback offers a controllable and explicit learning pathway, which aids in the establishment of writing confidence.

Notwithstanding these benefits, local linguistic feedback also demonstrates distinct limitations. Primarily, an excessive reliance on surface-level error correction tends to lead learners to concentrate on linguistic forms while neglecting content development and the quality of argumentation, thereby reinforcing ‘surface revision’ rather than deep-level meaning construction^[28]. Certain studies suggest that when confronted with a high volume of error annotations, learners may experience ‘feedback fatigue’, inclining them towards the mechanical acceptance of modifications without a comprehension of the root causes of errors or linguistic functions. Secondly, the frequent provision of overly granular correction suggestions by systems may attenuate learner self-monitoring capabilities, causing them to become reliant on technology during the writing process and reducing their willingness to actively detect errors. Additionally, as local feedback from AI systems may exhibit inconsistencies or misjudgements, learners lacking feedback literacy find it difficult to assess feedback quality, potentially leading to negative transfer when erroneous feedback is adopted^[29].

In summary, while local linguistic feedback remains a vital foundation for improving linguistic accuracy within AI writing feedback, its genuine pedagogical value is contingent upon whether learners can integrate this surface-level information into broader writing objectives and the process of meaning construction. Consequently, in actual instruction and system design, it is necessary to combine local feedback with other types of feedback. This integration serves to guide learners away from overly formalised and fragmented revision behaviours, promoting holistic development at both the linguistic and content levels.

3.2 Global Feedback

Global feedback is primarily orientated towards the macro-organisational and meaning-construction dimensions of writing. Its focal points encompass the rationality of discourse structure, the logical progression between paragraphs, the coherence and completeness of argumentation, and the clarity and sufficiency of thesis statements. Distinct from local linguistic feedback, global feedback is not restricted to isolated sentences or vocabulary; rather, it evaluates the text holistically to determine whether the intended communicative purpose has been achieved. For instance, systems may flag issues such as ‘unclear overall logic’, ‘lack of effective transitions’, ‘indistinct paragraph topic sentences’, or ‘insufficient evidentiary support’, thereby guiding learners to ameliorate their writing from the perspectives of overall structure and content development^[30].

Propelled by technological advancements, certain AWE systems and the new generation of generative AI tools (such as the GPT series and Write Wise) have acquired the capability to provide relatively complex evaluations and suggestions at the discourse level. These include paragraph reorganisation, analysis of argumentative coherence, and judgements on content coverage. Research indicates that this category of global feedback holds significant value for fostering higher-order writing competencies in learners. Particularly within academic and argumentative writing, it assists students in comprehending argumentative structures and strengthening logical consistency both within and between paragraphs^[31]. Furthermore, global feedback directs learner attention towards writing task requirements and the target audience, thereby enhancing overall writing quality and rhetorical effect^[32].

The effectiveness of global feedback varies considerably among learners because it is abstract and relies on metacognitive processes such as clarifying writing purposes, reasoning logically and planning discourse. Learners therefore need strong

language proficiency and monitoring abilities to interpret and apply it. When told that “paragraph organisation is problematic” or “argumentation lacks hierarchy,” they often have to reassess and reorganise the whole text, which imposes far greater cognitive load than handling linguistic errors and may lead those with weaker foundations to struggle or even avoid using such feedback. At the same time, AI tools still face limitations in providing global feedback; constrained discourse analysis can produce overly general, ambiguous or non-actionable suggestions, reducing learner trust and uptake. As a result, the actual impact of global feedback depends on the interaction among technological quality, pedagogical support and learners’ feedback literacy^[33].

Overall, global feedback possesses irreplaceable pedagogical value in enhancing higher-order writing skills. However, its effective utilisation must be predicated on the learner possessing sufficient cognitive resources and strategic capabilities. It simultaneously necessitates that systems provide suggestions that are logically clear and highly actionable, to facilitate deep revision by learners at the levels of writing planning and meaning construction.

4. Learner Engagement and Behavioural Response to AI Writing Feedback

4.1 Cognitive Interpretation and Trust Mechanisms

Learners’ cognitive interpretation of AI feedback and their degree of trust constitute the psychological mechanism that transforms feedback into concrete revision behaviours. Existing studies show that learners are not passive recipients but make final decisions through judgement, comparison and selective processing, meaning that the effectiveness of AI feedback depends not only on system quality but also on cognitive and affective trust. High trust promotes rapid adoption based on the principle of least effort, especially for clear surface-level errors, leading to a high-adoption surface revision pattern^[34]. When trust is ambiguous, learners alternate between acceptance and scepticism or use AI merely to verify their own ideas, increasing cognitive load but also preserving writing autonomy. Low trust relegates AI to a secondary checking tool used mainly for polishing or spelling, while deeper evaluation of logic or structure is rejected and replaced by teacher authority or learners’ own linguistic knowledge^[34]. External contexts further modulate this relationship: in high-stakes academic settings, learners act cautiously due to fear of misalignment with assessment standards or teacher expectations, with institutional norms playing a decisive role^[35]; in low-risk, autonomy-oriented environments, they are more inclined to treat AI as a private tutor for explanations, examples and structural guidance^[36].

Overall, accurate comprehension and moderate trust form the psychological foundation for effective AI-assisted writing, and future research should attend to systemic factors influencing trust such as algorithmic transparency, explainable feedback design and the development of student feedback literacy.

4.2 Revision Intention and Extent

Revision intention acts as a critical precursor to behavioural investment. It denotes the learner’s plan to modify text following feedback. In generative AI contexts, this intention relies on the perceived value of feedback and its alignment with task objectives. Learners are more likely to revise when suggestions effectively enhance text quality or adhere to specific genre norms. Furthermore, clarity and actionability represent vital mechanisms. Schiller et al.^[37] indicate that transparent feedback with executable pathways effectively alleviates cognitive load. Conversely, ambiguous suggestions increase comprehension costs and weaken motivation. External factors such as time pressure and self-efficacy also moderate this process. Empirical studies by Fu and Liu^[38] and Crosthwaite and Sun^[39] corroborate that specific and high-quality feedback significantly strengthens revision intention.

Revision extent constitutes a multidimensional construct encompassing both quantitative breadth and qualitative depth. Breadth refers to physical variations like word count. Depth pertains to cognitive levels and structural hierarchy. The feedback modality exerts a significant influence here. Traditional AWE often prompts local linguistic corrections. In contrast, GenAI facilitates substantial text modification through rewriting suggestions. However, large-scale revision does not invariably equate to deep cognitive investment. Some students merely adopt AI content without critical reflection. Others engage in deep re-creation. Process data analysis reveals distinct behavioural pathways. Schiller et al.^[37] note that high-engagement learners exhibit recursive editing modes. Low-engagement learners frequently demonstrate linear and rapid acceptance. Consequently, mere revision quantity is insufficient to measure effectiveness. It must be evaluated alongside the cognitive investment

involved.

4.3 Affective and Motivational Responses

AI writing feedback serves as more than a mere cognitive resource for information transfer. It functions as a psychological trigger capable of significantly stimulating learner affective responses and motivational shifts. This influence is characterised by distinct complexity and duality.

On the one hand, immediate and effective AI feedback can ameliorate emotional experiences by alleviating cognitive load. Language barriers frequently precipitate high levels of anxiety within L2 writing contexts. Research by Rahman et al.^[40] indicates that immediate feedback and visualised text improvements provided by AI effectively bolster student self-confidence in writing. These features also mitigate writing anxiety. Consequently, a positive reinforcement loop for learning is established.

Conversely, technological limitations may incite negative affective blockages. Learners are prone to feelings of frustration and confusion when AI systems frequently flag errors without sufficient explainability. Similar reactions occur when there is significant dissonance between AI feedback and teacher evaluation criteria. If such cognitive conflict remains unresolved, it may lead students to develop technological mistrust. This subsequently inhibits their motivation to utilise these tools for learning support^[40].

Furthermore, the dimension of affective response has expanded from simple mood fluctuations to deeper crises regarding morality and identity with the intervention of Generative AI (GenAI). The robust generative capabilities of GenAI have reshaped the nature of human-computer interaction. This makes student emotional experiences replete with contradictions. A study by Teng^[17] found that some students perceive tools like ChatGPT as collaborative partners. They emphasise emotional reliance on these tools for cognitive expansion and writing support alongside their positive value. In contrast, other students exhibit significant apprehension. They worry that excessive reliance on AI might undermine individual writing agency or trigger ethical concerns regarding academic integrity. This psychological struggle between tool empowerment and competence deprivation constitutes a unique affective landscape in current AI writing education.

5.A Comprehensive Conceptual Framework for AI Writing Feedback

Drawing on the systematic literature review, this study proposes a conceptual framework that explains how AI writing feedback is transformed into revision behaviours and writing outcomes through a chain of cognitive and affective processes. The core pathway consists of six linked components: feedback characteristics, cognitive assessment, feedback satisfaction, revision intention, revision extent, and writing outcome. The framework highlights that AI feedback does not directly improve writing performance. Instead, it works through a series of mediating mechanisms shaped by learner perceptions^[41].

Feedback characteristics form the initial input affecting cognitive assessment. Key dimensions include feedback type (e.g., local linguistic vs. global discourse feedback), quality (e.g., accuracy, specificity, consistency), and interactive load (e.g., information volume and interface presentation). Based on these features, learners develop cognitive judgements concerning credibility, task relevance, and comprehensibility^[42].

Cognitive assessment then shapes overall feedback satisfaction, which combines evaluative judgement with affective responses. As a central mediator, satisfaction strongly predicts revision intention and influences whether learners engage in surface-level or deep-level revision. Evidence from AWE and generative AI research consistently shows that high satisfaction promotes active uptake, whereas deep revision occurs only when learners invest substantial cognitive effort^[43].

The final stage concerns writing outcomes, including both product-oriented indicators (linguistic accuracy, discourse structure, argument quality) and capability-oriented indicators (self-efficacy, metacognitive strategies, long-term writing development), forming a complete loop from technical input to learning effectiveness^[44].

Overall, this framework contributes to theory building by clarifying the dynamic relationships between feedback characteristics, learner cognition, and revision behaviour, identifying feedback satisfaction as a key psychological mechanism, and underscoring the value of process data such as revision logs and behavioural trajectories for future empirical research on AI-supported writing.

6. Methodological Challenges

Contemporary scholarship regarding AI writing feedback exhibits a notable deficiency in the depth and multidimensionality of data collection. This deficit is primarily characterised by a scarcity of process data alongside a potential disjunction between self-reported information and actual behaviour. Certain vanguard studies have commenced attempts to utilise keystroke logging, screen recording, and learning analytics to capture micro-revision behaviours within AI feedback contexts^[45]. However, the prevailing paradigm remains excessively reliant on summative evaluations derived from pre-test and post-test scores. Consequently, there is a lack of quantitative description and deep mining regarding the intermediate revision process. Current revision classification systems are predominantly predicated on time-consuming manual coding^[46]. These systems have not yet fully leveraged large-scale log data and natural language processing tools for automated analysis. As a result, research struggles to unveil the dynamic cognitive trajectories inherent in learner-AI interactions^[47]. More critically, exclusive reliance on self-reported data such as questionnaires and interviews may lead to severe measurement bias. Research findings indicate that high levels of self-reported satisfaction by students do not necessarily translate into high levels of actual revision behaviour or substantive writing improvement. This inconsistency between subjective and objective data necessitates that future inquiries adopt multi-source data triangulation strategies^[48]. It is essential to combine subjective perceptual data with objective behavioural data, such as revision logs and version comparisons, to enhance the internal validity of research conclusions.

Regarding the temporal dimension and research design, the prevalence of short-term and single-task orientations constitutes another major methodological bottleneck within the field. A vast number of studies tend to employ one-off writing tasks or short-cycle experimental designs^[49]. Consequently, researchers often struggle to capture the sustained effects and transfer value of AI writing feedback on the long-term development of learner writing competence. Such cross-sectional designs are highly susceptible to interference from the novelty effect. This implies that positive reactions exhibited by learners may stem more from the freshness of new technology rather than genuine cognitive investment or capability enhancement. This phenomenon often leads to an overestimation of the actual pedagogical efficacy of AI tools^[50].

Furthermore, rapid technological iteration and the limitations of research contexts pose severe challenges to the external validity and reproducibility of findings. The update velocity of generative AI technology is extremely fast. It is a common occurrence that the system version used in a study has undergone fundamental changes by the time of publication. This creates a common difficulty for cross-study comparison and replication^[51]. Concurrently, sample sources in existing literature exhibit significant geographical imbalance. They are concentrated primarily in higher education contexts within Europe, America, China, Japan, and South Korea. Conversely, empirical evidence from basic education stages in Southeast Asia, the Middle East, and non-English speaking countries remains relatively scarce. This cultural singularity of samples makes it difficult to isolate the contextual influences of culture and educational systems. Consequently, it is challenging to determine whether existing findings possess universality or are merely products of specific cultural backgrounds^[40].

7. Conclusion and Future Directions

AI writing feedback technology has undergone a significant paradigm shift. It has evolved from early local error correction tools represented by Automated Writing Evaluation (AWE) to generative AI ecosystems capable of providing multi-layered and conversational support^[42]. Overall, existing evidence indicates that AI writing feedback possesses immense potential to enhance learner writing quality and self-efficacy under appropriate instructional design and usage conditions. However, the efficacy of this technology is not solely a result of the tool itself. Rather, it is highly dependent on learner cognitive understanding of the feedback, affective satisfaction, and subsequent concrete revision behaviours. Consequently, this study constructs a comprehensive conceptual framework. This framework encompasses AI feedback, cognitive assessment, satisfaction, revision intention, revision extent, and writing outcomes. It reveals from a theoretical perspective how feedback characteristics are transformed into actual writing behaviours through the subjective psychological experiences of the learner. Furthermore, it confirms the critical mediating role played by satisfaction in connecting technical characteristics with behavioural performance.

Future academic exploration requires a fundamental transformation at the methodological level from a result-orientated approach to a process-orientated one to further validate and deepen this theoretical framework. The research emphasis must shift from mere writing score evaluation to micro-process analysis combining keystroke logging, version control, and learning analytics technologies. It is essential to construct revision mechanism models based on behavioural data. This will allow for the precise quantification of the specific contributions of surface and deep revisions to writing quality. Concurrently, future empirical designs should transcend the laboratory paradigm to address the limitations of short-term effects prevalent in current research. Longitudinal and ecological research pathways are required. Researchers can circumvent the interference of the novelty effect by deeply integrating AI tools into long-cycle curriculum systems. This approach also allows for a profound comparison of the differential efficacy of diverse pedagogical modes. These modes include teacher-feedback dominance supplemented by AI, AI-feedback dominance regulated by teachers, and hybrid models combining AI and peer feedback. Such comparisons will provide empirical grounds for different educational contexts.

Finally, the widespread application of AI writing feedback must be scrutinised under a framework of human-machine synergy sustainability and ethics. At the level of pedagogical practice, educators should design specialised units for feedback literacy and metacognitive training. The focus should be placed on cultivating learner abilities to screen AI suggestions critically and process them deeply. Additionally, the role of the teacher must transform from a basic error corrector to a guide of higher-order thinking. At the institutional level, it is imperative to establish clear ethical norms and policy guidelines. These measures are necessary to balance the tension between technological empowerment and academic integrity within curriculum and institutional spheres. In summary, the future development of AI writing feedback lies not only in the enhancement of algorithmic precision. It relies more significantly on constructing a responsible and learner-centred hybrid feedback ecosystem within multi-cultural contexts. This is the path to truly realising the deep empowerment of writing education by technology.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Analysis of the Current Development of the Youth Amateur Basketball Training Market and Optimization Strategies

Mingming Li, Xiang Zhang*

Hefei Preschool Education College, Hefei, 230000, China

*Corresponding author: Xiang Zhang, 359310716@qq.com

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Abstract: To examine the current conditions of youth amateur basketball training institutions, this study takes the basketball training market in Fuyang City, Anhui Province, as an illustrative case. A mixed-method design was adopted, integrating literature review, questionnaire surveys, and expert interviews. The analysis focused on three stakeholder groups: training institutions, participating students and their parents, and institutional managers and coaches. The findings indicate that, although the market has continued to expand, venue and facility conditions have improved, and demand among students and parents has increased, several constraints persist. These include a limited range of business models and financing channels, insufficiently effective governmental oversight, tensions between academic commitments and training participation, shortages of personnel with management and instructional expertise, and inadequate provision of theoretical knowledge in training programs. In response, the study proposes the following measures: refining operational models and introducing broader social resources; strengthening governmental regulatory mechanisms; advancing the integration of sports and education through enhanced school–enterprise collaboration; establishing professional talent teams and developing the coaching workforce; and increasing the teaching of theoretical content. These recommendations are intended to provide a conceptual basis for regulators and institutional operators seeking to improve the basketball training market.

Keywords: Basketball Training; Sports Industry; Coaches; Adolescents

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1.Introduction

In recent years, national economic development has continued, and household consumption attitudes have shifted accordingly. In addition to subjects commonly regarded as core academic areas (e.g., Chinese, mathematics, and English), parents have shown growing interest in cultivating children's individual skills. Attention is no longer directed solely toward academic performance; greater emphasis is also placed on physical fitness, as well as on supporting healthy growth and development. Within this context, family investment in children's participation in physical activity has increased. Following the introduction of the “double reduction” policy, sports training providers of various types have expanded in number^[1]. Among these programs, basketball is widely favored by adolescents. Participation in basketball can contribute to physical fitness and, at the same time, supports the development of communication skills, teamwork, and volitional qualities. Youth amateur basketball training institutions therefore serve multiple functions, including improving youth physical fitness, fostering sustained exercise habits, cultivating competitive talent, and expanding the basketball-participating population^[2].

They also provide an important extracurricular extension to school-based basketball instruction^[3]. Against this background, the present study adopts optimization strategies for the basketball training market as its analytical entry point, investigates and analyzes the current state of the basketball training market in Fuyang City, and proposes corresponding strategies aimed at supporting orderly market development^[4].

1.1 Research Subjects

The primary focus of this study is the optimization strategies for the basketball training market in Fuyang City, Anhui Province. The survey sample comprised five basketball training institutions, Shandong Sibote Sports, Shandong Huiyang Sports, Aoguan Basketball Club, Yanshan Basketball Club, and Hupu Basketball Club, as well as 100 trainees, 30 coaches, and 6 managerial staff members.

1.2 Research Methods

(1) Literature Review

Using “adolescents,” “basketball training,” and “sports industry” as keywords, 57 articles were retrieved from the CNKI database to provide a theoretical basis for the study.

(2) Questionnaire Survey

Field visits and on-site investigation were conducted at Anhui Sibote Sports, Fuyang Huiyang Sports, Aoguan Basketball Club, Shuanglong Basketball Club, and Hupu Basketball Club. Based on this work, three instruments were developed: the Coach Questionnaire, the Management Staff Questionnaire, and the Trainee Questionnaire. The surveys were distributed to 6 managerial staff members, 30 coaches, and 100 trainees aged 6–12 years, and subsequently collected.

(3) Expert Interviews

Face-to-face interviews were conducted with managers and coaches from the five basketball training institutions to obtain relevant data and supporting materials for the study.

3. Results and Analysis

3.1 Current Development of the Youth Basketball Training Market in Fuyang City

Basketball training institutions in Fuyang City have become an important extracurricular extension of school physical education. To some extent, they have supported the development of regional basketball, while also contributing to youth physical development, the expansion of basketball participation, and the promotion of national fitness and mass sports^[5]. Overall, demand for basketball training is relatively high. Most institutions operate their own venues, and the basic conditions of facilities are generally in place. At the same time, as basketball training is an emerging sector, a range of issues has accompanied its rapid growth, which may affect the orderly development of these institutions^[6].

(1) A Single Business Model and Limited Diversification of Funding Sources

The survey indicates that most basketball training institutions in Fuyang City mainly offer basketball interest-based classes. In contrast, programs such as early-childhood basketball courses, one-to-one basketball coaching, physical education training oriented toward the secondary school entrance examination, and advanced technical–tactical courses are offered less frequently. Market segmentation therefore remains limited, and some trainees’ needs are not met^[7]. In addition, as adolescents develop, participation in multiple sports can support the development of diverse physical functions; however, many institutions provide basketball training as their only service. This limited product portfolio is associated with an incomplete profit model^[8], relatively low profitability, and a pattern in which larger institutions may generate less profit. Revenue is derived primarily from trainees’ tuition and training fees, which results in a narrow funding structure and limited input from social capital. As a consequence, funding is less stable, and it is difficult to allocate sufficient resources to coach development and to facility upgrading^[9].

(2) Insufficient Government Oversight and the Need for Further Market Standardization

In recent years, policies promoting mass participation in sport have coincided with the expansion of amateur basketball training institutions. Corresponding supervisory arrangements from relevant government bodies, however, have not been established in a systematic manner, and the policy and regulatory framework remains incomplete, leaving the market in a less regulated condition^[10]. With rising demand and associated economic returns, many institutions have entered the market.

A portion of these providers lack the required qualifications and have not completed registration with relevant authorities; their venues, facilities, and coaching teams may also be unable to ensure training services that meet expected standards. In this context, a low market-entry threshold and limited oversight can make training quality difficult to assure^[11], which is not conducive to the orderly development of the basketball training market. Pricing mechanisms are also subject to limited regulation. To compete for enrollment, many institutions reduce per-class fees and engage in price-based competition; costs are then offset by reducing coaching expenditures and lowering venue and facility standards. This form of competition can weaken course content and product quality. In addition, unified certification standards for coaches across institutions are not in place. From the perspective of parents, coaches' claimed experience is difficult to verify and is often presented only through institutional promotion, which limits the basis for assessing coaching competence. Government agencies have also provided limited guidance for collaboration between schools and private sports training institutions. Schools often have access to large student populations and comparatively complete and specialized facilities, whereas private institutions may have coaching resources aligned with specialized training needs. When cooperation is limited, implementation of the "integration of sports and education" approach is constrained^[12].

(3) The Academic–Training Conflict Constrains Sustained Participation

Based on the preceding findings, ages 12–16 represent a period in which adolescents' physical functions and sport-specific skills are expected to develop, and this age group would, in principle, be positioned to participate frequently in organized training. The observed pattern does not align with this expectation. A key explanation lies in the tension between China's sport system and education system, often described as the "academic–training conflict" (xuexun maodun). Over the course of sports development in China, this conflict has remained a persistent governance and implementation issue. As competitive standards rise across teams at different levels, athletes are often required to allocate substantial time to sport-specific technical training and physical conditioning, which creates a conflict between training demands and schooling. Within schools, although student participation resources are extensive, examination-oriented pressures tend to shift institutional priorities toward progression rates, and organized sports training receives comparatively less attention. In summary, the education and sport systems have not formed a shared understanding of talent-development objectives, and differences remain in their respective targets. Consequently, adolescents aged 12–16—typically regarded as a key period for athlete development—often face academic pressures associated with transitions such as entry into junior secondary school and the secondary school entrance examination. Parents may therefore be required to choose between training and academic study. The survey indicates that trainee attrition is highest in the 12–16 age group, with excessive academic pressure reported as the main reason. Some trainees who have undergone long-term development or who demonstrate strong potential also discontinue training in response to advancement-related pressures. Under market conditions, this constrains institutions' capacity to sustain higher-level training programs and leaves unmet demand for professionalized pathways; more importantly, it reduces the continuity of reserve talent development.

(4) Shortages of Specialized Personnel Constrain Institutional Sustainability

Regarding institutional management, most managers in basketball training institutions are former athletes or graduates from sport-related university programs. While they may possess teaching experience and disciplinary knowledge, they may lack training in management and economics, which can limit their capacity to assess market conditions and diversify marketing approaches. Basketball training also has sector-specific features; general management knowledge alone may be insufficient without an understanding of basketball as a sport and its training logic. From this perspective, institutions lack senior, interdisciplinary personnel who combine management expertise with basketball-specific theoretical knowledge. With respect to coaching, the survey suggests that coaches in Fuyang City's basketball training institutions face challenges that include comparatively lower formal educational attainment, incomplete theoretical preparation, recruitment channels that are not well aligned with professional requirements, and underdeveloped training and development systems. These conditions can affect course quality and, in turn, influence longer-term institutional development. Competition between organizations is closely linked to competition for human resources. When the market is at an early stage and institutions rely on a relatively uniform operational model, the effects of staffing constraints may be less visible. As the market shifts toward greater diversification

and the sector continues to evolve, limitations in personnel structure become an increasingly important factor shaping institutional development.

(5) Insufficient Theoretical Instruction Affects the Development of Comprehensive Competencies

In the curriculum of basketball training institutions, many coaches focus primarily on sport-specific skills and physical conditioning. Some coaches incorporate game-based activities to support engagement during training. The proportion of content devoted to theoretical instruction, however, is limited. Many parents also have limited understanding of basketball, and they tend to prioritize improvements in children's skills and physical performance. Under these conditions, coaches in community-based training settings may place less emphasis on delivering necessary theoretical knowledge. Over time, trainees may improve in fundamental techniques and fitness indicators, yet their knowledge of competition rules and tactical principles may not develop to the same extent. As a result, although many trainees acquire a certain level of skill and physical capacity, their performance in formal games may not correspond to these capacities, particularly in situations that require rule application and tactical decision-making.

3.2 Optimization Strategies for the Youth Basketball Training Market

(1) Refining Operational Models and Broadening Funding Sources

Basketball training institutions can pursue commercial cooperation with social enterprises, with the aim of diversifying their funding structures. Through resource integration and the introduction of external resources, institutions may obtain additional funding channels, which can be allocated to coach training, course improvement, and organizational expansion. Capital participation may also facilitate the entry of personnel with experience in economic and managerial roles into the basketball training sector; in this sense, cross-sector resource inflows into sports training may constitute a direction for future sectoral development. In terms of product design, institutions can strengthen market segmentation rather than focusing only on interest-based classes. Training programs can be developed for different potential client groups, with course content and formats adjusted to reflect varied needs. A more diversified portfolio of sports training services can respond to consumers' interest in multiple activities, support adolescents' overall physical development, and encourage repeat consumption among members, thereby reducing costs associated with re-acquiring clients. In Fuyang City, many basketball training institutions have limited venue capacity for adding new sports. Under such constraints, institutions can explore cooperative models with providers in other sports to share resources and meet multi-sport demand; for example, collaborations with swimming training providers during summer vacation represent one feasible approach for increasing operational diversity.

(2) Improving Government Regulatory Mechanisms and Standardizing Market Order

As the basketball training market expands, government agencies can establish corresponding market-entry and raise entry thresholds. This can include strict review of institutional qualifications, together with explicit standards for venues and facilities, coach qualifications, course content, and safety management. Training institutions can be registered and placed on record, while institutions that do not meet entry criteria can be removed from the market; at the same time, enterprises with adequate capacity and a sense of social responsibility can be encouraged to participate in the sector. In coach management, unified standards can be developed for qualification review, in-post training, teaching practice, and evaluation of instructional quality. Such standards can reduce the incidence of institutions or coaches operating without required credentials and can align staffing with role requirements. Market governance can be strengthened on a continuing basis through oversight, incentives, and guidance, so that institutions move toward more standardized practices in qualifications, competition behavior, staffing standards, and teaching quality. This can support competition that is oriented toward quality rather than price-based escalation. In addition, cooperation between public schools and non-public sports education institutions can be promoted, which may increase the utilization of school sports facilities and reduce the underuse of educational resources, thereby supporting market development within an ordered framework.

(3) Advancing the Integration of Sports and Education and Strengthening School–Enterprise Collaboration

Misalignment between the education system and the sport system in talent-development arrangements is commonly regarded as one factor shaping the development of youth basketball training. From this perspective, the “integration of sports and education” framework provides a policy pathway for addressing related constraints. As a direction for future development,

training institutions and schools can strengthen communication and cooperation so that coordination between school-based sport and external training becomes more workable in practice. For schools, training time can be arranged in a way that avoids excessive encroachment on academic class time while also ensuring that scheduled training is not compressed. Training efficiency can be improved so that students obtain gains within limited training time. Social resources may also be used to help address the academic–training conflict. In the context of the “double reduction” policy, schools may introduce external sports resources on a paid basis to meet students’ needs for skill development; this may include bringing qualified, reputable organizations or training institutions into schools, provided that they meet compliance requirements and have no record of violations. For enterprises and training institutions, active collaboration with schools can enable fuller use of school sports venues and facilities, which may reduce underutilization of venue resources. Cooperation can also facilitate the provision of training programs that align with students’ development needs, support school sport development, and strengthen pathways for talent identification and progression. In addition, engagement within school contexts can shape brand recognition among parents and students. On this basis, institutions can focus on improving instructional quality, developing coaching capacity, and establishing a brand image aligned with service standards.

(4) Building Professional Talent Teams and Enhancing Coaching Capacity

As the individuals responsible for institutional management and operations, managers influence whether basketball training institutions can achieve sustainable profitability. Their ability to identify market trends in a timely manner, design marketing approaches, and coordinate operational arrangements constitutes a basis for assessing managerial competence^[13]. For this reason, managers in basketball training institutions need sport-specific theoretical knowledge as well as professional training in management and economics, and they are expected to function as interdisciplinary personnel who understand both management and sport. Institutions can improve managerial capacity through two routes: providing re-training for current managers and recruiting dedicated professionals with relevant management expertise.

Coaches, as organizers and facilitators of training activities, play a leading role in program delivery. In Fuyang City, constraints reported for coaches in basketball training institutions include relatively low entry thresholds, loose management arrangements, unstable recruitment channels, and limited internal development systems; these factors have become important conditions shaping institutional development. From this perspective, the development of amateur basketball training institutions requires a stable and professional coaching team.

To strengthen coaches’ professional and practical competence, several measures can be considered. A regulated entry threshold can be established, with systematic review of coaching qualifications and clear requirements for educational attainment among practitioners. Credential-based employment can be implemented, and coaches may be required to hold at least one certificate recognized by education or sport administrative authorities, such as a coaching qualification certificate issued by the Chinese Basketball Association or a physical education teacher qualification certificate. A stable recruitment channel also supports improvements in staffing. Institutions may cooperate with universities and conduct campus recruitment. This approach can increase matching accuracy, as candidate information provided by universities enables targeted selection; in addition, candidates trained in higher education contexts often possess relevant theoretical preparation and practical experience. At the same time, such recruitment arrangements can expand employment opportunities for graduates and provide discipline-aligned students with a setting to apply what they have learned, thereby offering support for graduate employment outcomes. After hiring, a structured coach training system can support continued improvement in instructional practice. At present, coach development in Fuyang City’s basketball training institutions relies mainly on internal training. Although internal training can address institution-specific teaching issues, it may be constrained by the institution’s highest in-house coaching level. In response, institutions can organize periodic external training, learn from high-level institutions in other regions, develop a unified syllabus and teaching outline, and standardize age-appropriate training content across developmental stages. This can reduce the practice of adding training content that does not match trainees’ age and development in order to display short-term outcomes. In parallel, cooperation with university schools of physical education and basketball associations can be pursued to strengthen coaches’ theoretical knowledge and consolidate in-service training arrangements. In teacher management, an instructional quality review mechanism also constitutes an operational component.

Through systematic review, coaches can identify their strengths and limitations, which can inform instructional improvement. Institutions may evaluate coaches using indicators such as attendance, teaching hours completed, course development quality, student training outcomes, and parent feedback. On this basis, reward and sanction mechanisms, as well as recognition activities, can be established to support coaches' engagement in training and professional learning.

(5) Strengthening Theoretical Instruction to Support Broad-Based Development

Theory provides a reference for guiding practice. In routine training, coaches can integrate technical–tactical training, physical conditioning, and theoretical instruction within a coherent curriculum^[14]. Basketball-related theory can be taught in a systematic manner so that trainees can apply it in practice. This content may include basketball culture—such as the origin of the sport, sports ethics, and discussion of future development trends—as well as the application of technical skills, tactical approaches, and conditioning methods, including common errors and correction strategies. Through such instruction, students can learn when to use particular techniques, when to initiate specific tactical patterns, and how to compare the advantages and limitations of alternative options. This can support understanding of technical and tactical concepts and may also contribute to engagement in physical training. On this basis, coaches can explain relevant rules so that students understand what constitutes a violation, what constitutes a foul, and how to participate within the permitted scope of the rules, enabling more comprehensive mastery of competition regulations. Injury prevention and protection methods can also be included. For example, after acute injuries occur, trainees can be introduced to the “PRICE” principle as an approach to immediate response, so that they understand self-protection during exercise and basic steps for urgent handling following injury. By communicating the role of warm-up activities before training or competition and cool-down activities afterward, coaches can guide students to conduct preparation and recovery routines proactively; while supporting interest in sport participation, this approach can also contribute to the formation of exercise habits^[15].

4. Conclusion

With the ongoing expansion of integrated sectors such as sports training and education, the basketball training market in Fuyang City has also developed accordingly. At the same time, basketball training institutions continue to face issues that require attention, including weaknesses in operational management and the absence of effective oversight. Addressing these constraints through continuous improvement and targeted optimization can support the orderly development of the youth basketball training market. Such efforts may also create conditions for identifying and developing basketball talent in Fuyang City, while providing additional opportunities to extend extracurricular physical activity for primary and secondary school students.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Computer Vision-Based Structured Data Collection and Intelligent Grading of Paper-and-Pencil Homework

Qiang Wan*

Department of Lifelong Learning, Graduate School, Hanseo University, Seosan-si 31962, Republic of Korea

**Corresponding author: Qiang Wan, brick_wan@163.com*

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Abstract: Aiming at the problems of low efficiency in traditional paper-and-pencil homework grading and the difficulty of digitizing process data, this study proposes a solution to automate the collection and grading of free-format handwritten homework. To this end, a “cloud-edge-end” collaborative system architecture based on computer vision is proposed. The system first uses cascaded image preprocessing and deep learning semantic segmentation models to accurately analyze the homework layout and locate the question areas. It then employs handwriting recognition models trained with domain adaptation and formula recognition models with context perception of the question stem to complete the structural extraction of the answer content. Finally, combining rule matching and semantic similarity calculation, it achieves intelligent grading of both objective and subjective questions. Experimental results show that on the self-built real-world dataset, the proposed method significantly outperforms other methods in key tasks such as question area segmentation mIoU of 0.94, handwriting formula recognition accuracy of 86.4%, and objective question grading F1 score of 97.5%. It also demonstrates stronger robustness in dealing with challenges of image quality, layout complexity, and writing standardization, with an average performance degradation rate of only 11.3%. This study confirms that the proposed deep visual understanding approach can effectively tackle the key challenges of automated handwritten homework processing and provides an efficient and reliable tool for educational informatization in terms of data collection and intelligent grading.

Keywords: Paper-and-Pencil Homework; Computer Vision; Image Preprocessing; Deep Learning; Intelligent Grading

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Introduction

With the development of educational informatization, traditional paper-based homework grading methods have encountered limitations in efficiency^[1]. Teachers have to spend a lot of time manually correcting homework, recording grades, and tallying wrong questions, which is labor-intensive and susceptible to personal factors. Moreover, the learning process information in paper-based homework is not easily collected and analyzed, which hinders the implementation of precise teaching and personalized guidance^[2]. Although online learning platforms can automatically grade objective questions, it is still a challenge to achieve automated and intelligent processing for paper-and-pencil homework, which students use most frequently and which best reflects their cognitive processes, especially for those containing complex formulas, graphics, and subjective descriptions.

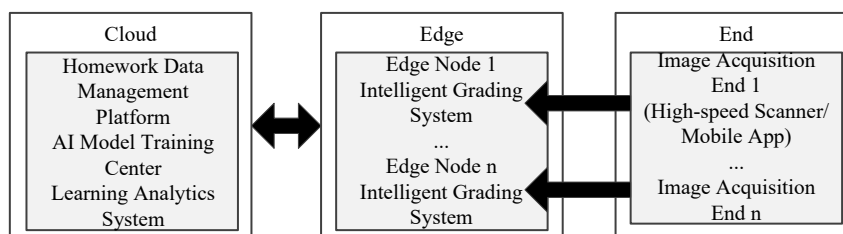
In recent years, the rapid development of computer vision and artificial intelligence technologies, especially the breakthroughs

of deep learning in image recognition, text detection, and understanding, has provided new ideas for solving the above problems^[3]. By using technologies such as intelligent photography, image rectification, handwriting recognition, and layout analysis, paper-and-pencil homework in the physical world can be efficiently and accurately converted into structured, computable data. This is not only a key prerequisite for achieving automated homework grading but also the data foundation for building learners' digital portraits and conducting in-depth analysis of learning conditions. However, current research or products mostly focus on standard answer sheets or printed text. For the complex scenarios of free-format handwritten homework, there are still many technical difficulties in handwriting blurriness, diverse layouts, and semantic understanding^[4]. Therefore, this study aims to explore and implement a complete solution based on computer vision to complete the image acquisition of general paper-and-pencil homework, the positioning and extraction of key information, content recognition and structured storage, and to preliminarily achieve intelligent grading and feedback for objective questions on this basis.

1. System Architecture Design

The computer vision-based intelligent grading system for paper-and-pencil homework is divided into three parts: cloud, edge, and end^[5]. The cloud center is responsible for storage and management. The edge side deploys the core algorithms for structured data collection and grading of homework. The end device is mainly used for the collection and upload of homework images. As shown in Figure 1, the homework data management platform is responsible for storing, managing, and scheduling all homework data. The AI model training center centrally trains and optimizes computer vision models. The learning situation analysis system performs data analysis and visualization based on the grading results. In the intelligent grading system, each edge node deploys a complete computer vision processing pipeline, including image preprocessing, layout analysis, text/formula recognition, structured extraction, and intelligent grading. The image acquisition end supports multiple acquisition methods (such as high-speed scanners, mobile apps), and completes the initial collection and upload of homework images. The end device collects homework images and uploads them to the edge node, which completes the core computer vision processing and grading. The cloud is responsible for centralized management, model updates, and macro analysis.

Figure 1 System Architecture



2. Design and Implementation of the Intelligent Grading System

2.1 System Workflow

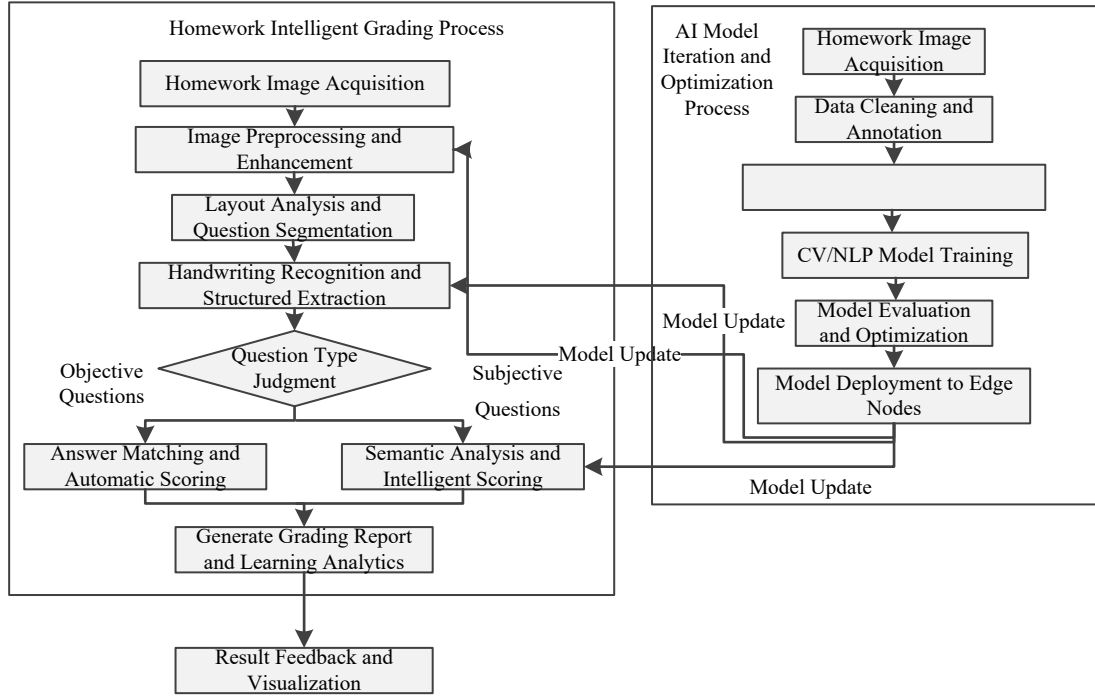
The intelligent grading system deployed on the edge node is based on computer vision technology to perform structured data collection and intelligent analysis on paper-and-pencil homework images^[6]. The system first preprocesses the homework images and analyzes the layout, and then recognizes and extracts various types of questions. For objective questions (such as multiple-choice and fill-in-the-blank questions), the system uses image recognition and pattern matching techniques to achieve automatic scoring. For subjective questions (such as short answer and calculation questions), the system combines optical character recognition (OCR), natural language processing (NLP), and formula semantic parsing algorithms to conduct intelligent analysis and scoring of the answers^[7]. The main workflow is shown in Figure 2.

As shown in Figure 2, the system workflow includes the following core steps:

(1) The system collects homework images through terminal devices and performs preprocessing such as noise reduction, skew correction, and illumination normalization to provide high-quality input for subsequent analysis. It uses computer vision models to understand the layout of the homework images, segment independent question areas, and converts students' answers into structured text data through OCR and handwriting recognition technologies^[8]. The system automatically

determines the question type based on the question characteristics. For objective questions, it performs rapid scoring through rules or pattern matching. For subjective questions, it calls the NLP models and formula parsers deployed on the edge nodes for semantic understanding, step-by-step analysis, or key point matching to achieve intelligent scoring. Based on the grading results, the system automatically generates a structured report containing correctness, scores, comments, and knowledge point analysis, and feeds it back to the terminal.

Figure 2 Workflow of the Intelligent Grading System



(2) The system continuously feeds the desensitized grading data back to the cloud. After data cleaning and labeling, the data is used for iterative training and optimization of computer vision and natural language processing models. The newly trained and validated models are deployed to each edge node, enabling the intelligent grading system to continuously evolve and become more accurate with use.

2.2 Intelligent Grading Algorithms

For multiple-choice and true/false questions, exact matching or fuzzy matching based on edit distance is used. Let the standard answer string be S_{std} , the student's answer string be S_{stu} , and the edit distance be $d(S_{std}, S_{stu})$. The similarity score can be defined as:

$$Score_{obj} = \left(1 - \frac{d(S_{std}, S_{stu})}{\max(|S_{std}|, |S_{stu}|)} \right) \times Full\ Mark \quad (1)$$

For short answer and calculation questions, multi-dimensional semantic matching is used. First, the standard answer key points $\{K_1, K_2, \dots, K_m\}$ and the student's answer v_{stu} are respectively transformed into semantic vectors $\{v_{k1}, \dots, v_{km}\}$ and v_{stu} . The cosine similarity between the student's answer and each key point is calculated as follows:

$$sim_i = \frac{v_{stu} \cdot v_{ki}}{\|v_{stu}\| \|v_{ki}\|} \quad (2)$$

If sim_i exceeds the threshold 0, it is considered to cover the key point. The final score is determined jointly by the number and quality of the key points covered:

$$Score_{sub} = \frac{\sum_{i=1}^m \delta_i \cdot (w_i \cdot sim_i)}{\sum_{i=1}^m w_i} \times Full\ Mark \quad (3)$$

Where $\delta_i \in \{0,1\}$ indicates whether the key point is covered, and w_i is the weight of the key point. For mathematical calculation questions, an additional symbolic computation library is introduced to check the equivalence of expressions.

2.3 Evaluation Metrics

True Positives TP - The system grades correctly, and it is actually correct. False Positives FP - The system grades correctly, but it is actually wrong (false positive). False Negatives FN - The system grades incorrectly, but it is actually correct (false negative). True Negatives TN - The system grades incorrectly, and it is actually wrong.

Accuracy is the most intuitive evaluation metric, representing the proportion of correct judgments among all grading results of the system. The formula is as follows:

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN} \quad (4)$$

Precision, also known as “positive predictive value,” focuses on the reliability of the grading results deemed correct by the system. In other words, it is the proportion of actually correct results among all the questions judged as correctly graded by the system. The calculation method is as follows:

$$Precision = \frac{TP}{TP + FP} \quad (5)$$

Recall, also known as “true positive rate” or “sensitivity,” primarily measures the system’s ability to identify all actual correct results. In other words, it is the proportion of correctly identified results among all the truly correct items (or answer key points). The calculation method is as follows:

$$Recall = \frac{TP}{TP + FN} \quad (6)$$

The F1 score, as the harmonic mean of precision and recall, aims to balance the two metrics in a single indicator. Given that precision and recall often trade off against each other in practical applications, the F1 score provides a comprehensive evaluation. The calculation formula is as follows:

$$F1 = \frac{2 \times Precision}{Precision + Recall} = \frac{2 \times TP}{2 \times TP + FP + FN} \quad (7)$$

3. Experimental Results and Analysis

3.1 Experimental Setup

This study constructed a real-world handwritten homework dataset named EduPaperBench-V1.0. The data was sourced from collaborations with multiple middle schools, covering three subjects: mathematics, physics, and chemistry, across three grades from the first to the third year of junior high school. The data collection followed a strict procedure, using standardized high-speed scanners and several mainstream mobile phones to capture images of daily after-school homework and unit test papers in various lighting environments such as classrooms and offices. Ultimately, 1,200 representative homework images were selected from the original image library, containing over 4,200 independent questions, forming the test set.

The edge node was configured with an NVIDIA Jetson Xavier NX, and the cloud training server was equipped with an NVIDIA RTX 3090 GPU. The algorithms were implemented using the PyTorch framework.

3.2 Experimental Results

3.2.1 Image Preprocessing and Layout Analysis Performance

The performance comparison of the three methods in the layout segmentation task is shown in Table 1. The fixed template matching has the lowest mIoU of 0.71. Its relatively high PSNR of 21.5 dB is due to its simple processing procedure and minimal image degradation, but this does not directly contribute to improving localization accuracy. Its only advantage is its extremely fast speed of 0.10 seconds per page. The rule-based handwriting OCR text matching has an mIoU of 0.82, which is an improvement over fixed template matching, indicating that reasoning through text content is feasible under certain conditions. However, its processing time of 1.80 seconds per page is significantly higher than the other methods, and it has the lowest PSNR. The method proposed in this paper achieved the best mIoU of 0.94, while maintaining excellent image quality with a PSNR of 22.8 dB and an efficient processing speed of 0.45 seconds per page.

Table 1 Performance Comparison in the Image Preprocessing and Layout Analysis Phase

Grading Methods	Average Intersection over Union for Region Localization (mIoU)	Peak Signal-to-Noise Ratio (PSNR)	Processing Time (seconds per page)
Fixed Template Matching	0.71	21.5	0.10
Rule-based Handwriting OCR Text Matching	0.82	20.1	0.18
Method Proposed in This Paper	0.94	22.8	0.45

3.2.2 Handwriting and Formula Recognition Accuracy Comparison

The recognition performance comparison results are shown in Table 2. The fixed template matching method performs extremely poorly in all recognition tasks. The Chinese handwriting Character Error Rate (CER) is as high as 68.5%, meaning that more than two-thirds of the characters cannot be correctly “guessed”; the formula recognition accuracy is only 22.7%. The rule-based OCR text matching method completely fails to recognize mathematical formulas, with an accuracy rate of only 0.2%. The method proposed in this paper achieves the best results in all metrics. The Chinese handwriting CER is reduced to 9.3%, and the English/number CER is reduced to 5.8%, with an overall Recognition Rate (R) of 14.1%. Most importantly, the mathematical formula recognition accuracy has reached a high level of 86.4%.

Table 2 Performance Comparison of Different Methods in Handwriting and Formula Recognition Tasks

Recognition Task	Fixed Template Matching	Rule-based Handwriting OCR Text Matching	Method Proposed in This Paper
Handwritten Chinese Recognition	68.5%	15.2%	9.3%
Handwritten English/Number Recognition	42.1%	8.7%	5.8%
Overall Handwritten Text Recognition	37.6%	24.5%	14.1%
Mathematical Formula Recognition	22.7%	0.2%	86.4%

3.2.3 Comprehensive Evaluation of Intelligent Grading Performance

The comprehensive performance comparison of different intelligent grading methods is shown in Table 3. The fixed template matching method achieved an acceptable accuracy of 89.5% and the highest precision of 91.2%, but its recall rate was the lowest at 87.1%, resulting in an F1 score of only 89.1%. This reflects the poor generalization ability of this method, which is only suitable for highly standardized examination scenarios and cannot cope with the diversity of daily homework. The rule-based handwriting OCR text matching method had an accuracy of 92.3% and an F1 score of 91.9%, and it could successfully extract answers for some relatively well-formatted homework. The method proposed in this paper achieved overwhelming advantages in accuracy (97.5%), precision (98.1%), recall (96.9%), and F1 score (97.5%), with very balanced performance across all metrics, demonstrating strong robustness and universality.

Table 3 Comprehensive Performance Comparison of Different Intelligent Grading Methods

Grading Methods	Accuracy	Precision	Recall	F1-Score
Fixed Template Matching	89.5%	91.2%	87.1%	89.1%
Rule-based Handwriting OCR Text Matching	92.3%	94.0%	89.8%	91.9%
Method Proposed in This Paper	97.5%	98.1%	96.9%	97.5%

3.2.4 Module-level Error Accumulation and Robustness Analysis

As shown in Table 4, the module-level error propagation analysis indicates that the fixed template matching method has a final grading accuracy of 89.5%, with some errors present. The rule-based OCR text matching method has a text accuracy of 84.8%, which is highly unreliable when dealing with complex layouts. The method proposed in this paper demonstrates a

positive, decoupled, and robust processing chain. It achieves high accuracy in region localization at 94%, ensuring the quality of the input from the source, and the system's final grading accuracy reaches 97.5%.

Table 4 Module-level Error Propagation Analysis

Grading Methods	Layout/Region Localization Accuracy	Content Recognition Accuracy (Text)	Content Recognition Accuracy (Formulas)	System's Final Grading Accuracy
Fixed Template Matching	71.0	31.5	22.7	89.5
Rule-based Handwriting OCR Text Matching	82.0	84.8	0.1	92.3
Method Proposed in This Paper	94.0	90.7	86.4	97.5

Table 5 shows the robustness stress test performance. The average attenuation rate of the fixed template matching method is as high as 45.2%. Under low-quality images (A) and complex layouts (B), the performance is 40.2% and 35.8%, respectively. The rule-based OCR text matching method has an average attenuation of 23.8%. The method proposed in this paper demonstrates excellent stability, with an average attenuation rate of only 11.3%, which is much lower than the former two, indicating that this method has a strong structural understanding capability.

Table 5 Robustness Stress Test Performance

Grading Methods	High-Quality Standard Dataset	Low-Quality Acquisition Set (A)	Complex Layout Set (B)	Non-standard Handwriting Set (C)	Average Attenuation Rate
Fixed Template Matching	89.5	40.2	35.8	85.1	45.20%
Rule-based Handwriting OCR Text Matching	92.3	75.1	70.4	68.9	23.80%
Method Proposed in This Paper	97.5	88.6	90.2	85.7	11.30%

4. Conclusion

This paper utilizes the “cloud-edge-end” collaborative framework and modular processing procedures to transform complex handwritten homework images into computable structured information, achieving highly accurate automatic grading. First, the use of deep learning-based image enhancement and semantic segmentation effectively parses various homework layouts, with an image quality PSNR of 22.8 dB and a processing speed of 0.45 seconds per page, laying a solid foundation for subsequent processing. Second, the professional recognition algorithms fine-tuned with in-domain data and formula recognition algorithms that consider context relationships achieve a mathematical formula recognition accuracy of 86.4%, significantly improving the precision of handwritten material transcription. Third, the system's step-by-step, separated construction effectively prevents the accumulation and amplification of errors, with an accuracy of 97.5%, precision of 98.1%, recall of 96.9%, and F1 score of 97.5%. Verified through multiple control experiments, it outperforms traditional methods. Fourth, after rigorous interference resistance testing, the average attenuation rate is only 11.3%, demonstrating that the system has better adaptability to various interference factors in real teaching environments.

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Research on Optimization Strategies of Youth Outdoor Camp Education from the Perspective of Sports Psychology

Han Chen*, Shunming Li, Kuifeng Wang, Yongwei Zhang

Guangxi Normal University, Guilin, Guangxi, 62100, China

*Corresponding author: Han Chen, 1319145336@qq.com

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Abstract: As an innovative form integrating nature, sports and education, outdoor camp education has significant value for the all-round development of young people. However, adolescents face multiple psychological challenges such as motivation, emotion and social interaction during participation. Based on the theoretical framework of sports psychology, this study systematically analyzes four major common psychological problems of young people in camps—low participation willingness, weak self-regulation, excessive competition and difficult interpersonal adaptation—through on-site investigations and interviews at Fosun Tourism & Culture Mini-Camp. On this basis, the study constructs a four-dimensional optimization strategy system including motivation stimulation, self-regulation improvement, sports spirit shaping and social adaptation promotion, and proposes an integrated implementation model and effect evaluation plan covering the pre-camp, in-camp and post-camp stages. This research aims to promote the in-depth integration of sports psychology and camp education, and provide theoretical reference and practical model for the professional development of the industry.

Keywords: Outdoor Camp Education; Adolescents; Sports Psychology; Optimization Strategies

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1.Introduction

In recent years, with the issuance of policies such as the Development Plan for the Outdoor Sports Industry (2022—2025), youth outdoor camp education, as an important part of quality education, has shown a strong development momentum. Through physical exercise, natural exploration and team life, it has irreplaceable value in cultivating young people's sound personality and social adaptation ability. However, camp education in China started relatively late. In practice, it often emphasizes activity processes and skill training, while ignoring the complex psychological dynamics of young people, such as motivation fluctuations, emotional ups and downs and social anxiety^[1]. If these psychological challenges are not effectively guided, they will weaken the educational effect and even bring negative experiences.

Sports psychology studies the laws of psychological activities of people in sports situations. Its theories and technologies on motivation stimulation, emotion management, attention regulation and team cohesion can precisely provide strong support for solving the above problems. This study aims to systematically introduce sports psychology into youth outdoor camp education^[2]. Taking Fosun Tourism & Culture Mini-Camp as an example, it analyzes the psychological problems of young people through on-site investigations and interviews, and constructs scientific optimization strategies to improve the quality of camp education and promote its scientific development^[3].

2. Theoretical Basis and Research Methods

2.1 Theoretical Basis

Sports psychology provides a solid theoretical support for camp education. Self-Determination Theory (SDT) points out that meeting individuals' basic psychological needs for autonomy, competence and relatedness can stimulate intrinsic motivation^[4]. Achievement Goal Theory distinguishes between task orientation and ego orientation, guiding young people to focus on personal progress rather than mere victory or defeat, which helps to enhance the fun of activities. Emotion Regulation Theory emphasizes that individuals can manage emotions through strategies such as cognitive reappraisal and relaxation techniques, which is crucial for coping with high-challenge situations in camps. Attention and Arousal Theory reveals the inverted U-shaped relationship between arousal level and performance, and technologies such as imagery training and self-talk can help young people maintain an optimal psychological state. Team Dynamics Theory shows that setting common goals and carrying out team-building activities can effectively improve task cohesion and social cohesion, and promote team collaboration^[5].

2.2 Research Methods

This study adopts a qualitative research approach, comprehensively using the literature review method, on-site investigation method, interview method and logical analysis method. From July to August 2025, the researchers participated in two sessions of Fosun Tourism & Culture Mini-Camp's "Guilin Natural Outdoor Exploration Camp" as observers, observing and recording the behaviors and emotional performances of about 60 campers aged 8-12 in activities such as stream trekking and rock climbing. At the same time, semi-structured interviews were conducted with 5 senior camp staff to gain an in-depth understanding of campers' psychological challenges and the current situation of response. Finally, using the logical analysis method, the observation and interview data were matched with sports psychology theories to construct optimization strategies^[6].

3. Analysis of the Current Situation of Youth Camp Participation and Psychological Problems

3.1 Low Willingness to Participate in Some Activities and Psychological Resistance

When facing high-challenge projects such as rock climbing and trapeze, some campers show behavioral withdrawal, negative emotions and low participation. The underlying reasons are as follows: first, frustrated competence needs and low self-efficacy—campers with weak physical fitness or lack of experience choose to avoid because they predict they "cannot do it"; second, social anxiety and lack of relatedness needs—introverted campers find it difficult to integrate into the group for fear of being laughed at; third, cognitive biases and fear psychology—excessive imagination of unknown environments and risks triggers strong fear; fourth, gender differences—some girls resist high-intensity activities due to physical burdens or social stereotypes^[7].

3.2 Insufficient Awareness of Rules and Self-Regulation Ability

In activities such as archery and fan painting, some campers show rule-breaking, distracted attention and impulsive behaviors^[8]. This is mainly due to the physiological limitations of adolescents' brain development—their prefrontal cortex is not yet mature, resulting in weak impulse control ability. At the same time, egocentric thinking mode, unstable attention and weak ability of delayed gratification also make it difficult for them to understand and abide by rules.

3.3 Weakened Sports Spirit and Emergence of Excessive Competition Tendency

In competitive activities, some campers overemphasize victory or defeat, feeling frustrated when losing and mocking opponents when winning, ignoring the process and cooperation. This reflects the deviation of their achievement goal orientation, which overly binds self-worth with comparison with others. In addition, the internalization of the social and cultural concept of "striving for the first" and the insufficient understanding of sports spirit are also important reasons.

3.4 Difficulties in Adapting to Collective Life and Interpersonal Frictions

In the early stage of camp, some campers have stress reactions such as homesickness and insomnia. In collective life, due to differences in living habits, lack of social skills and insufficient empathy, conflicts between roommates and social isolation of

some campers occur from time to time. The main crux lies in psychological stress caused by sudden environmental changes and lack of experience in dealing with interpersonal relationships independently.

4. Construction of Optimization Strategies from the Perspective of Sports Psychology

To address the common problems in current youth outdoor camp education, such as insufficient participation motivation, weak rule awareness, difficult team collaboration and poor social adaptation ability, this study constructs a systematic psychological intervention and optimization strategy based on the core theories and methods of sports psychology^[9]. The strategy aims to organically integrate psychological skill training into the entire process of camp activities, and fundamentally promote the all-round development of young people's psychological quality.

4.1 Strategy for Stimulating Motivation and Enhancing Participation Willingness: "Bringing In"

The core goal is to transform young people's passive participation attitude and stimulate their intrinsic motivation, with the key lying in meeting their three basic psychological needs for autonomy, competence and relatedness.

1. Implement "step-by-step" goal setting. According to Goal Setting Theory, specific, challenging and achievable goals can effectively guide behaviors and stimulate efforts. In practice, the "SMART" principle can be introduced at the opening ceremony to guide campers to set specific goals. For high-altitude challenge projects, design personal "courage ladder" task cards, decomposing the final goal into multiple sub-goals that can be completed step by step (e.g., rock climbing can be divided into equipment wearing, touching rock holds, climbing to different heights, etc.), and giving immediate recognition after each step. Emphasizing the setting of process goals (such as "maintaining stable movements") rather than only focusing on results (such as "winning") helps to shift attention to technical mastery and reduce anxiety about failure.

2. Construct a supportive self-efficacy system. Self-efficacy stems from successful experience, vicarious experience, verbal persuasion and emotion regulation. In activities, the principle of "low starting point and high development" should be followed^[10]. In the early stage, easy-to-succeed links should be set to help campers build confidence. Before high-difficulty projects, arrange coaches or peers to demonstrate and share experience, providing vicarious learning models. Coaches' feedback should adopt the "sandwich method" (affirmation-suggestion-encouragement), focusing on praising efforts and progress. At the same time, teach simple emotion regulation skills, such as deep breathing or positive self-talk (e.g., silently saying "I can do it") before challenges.

3. Create a "family-like" sense of belonging. Satisfying the need for relatedness can significantly enhance intrinsic motivation for participation. In the early stage of camp, carefully designed ice-breaking and team-building activities (such as collaborative games) should be carried out to accelerate the integration of members. Encourage each group to create unique team cultural symbols such as team names and slogans to strengthen collective identity. Arrange fixed group sharing time every day to encourage members to communicate their feelings of the day, providing a safe space for emotional expression and promoting mutual understanding and support.

4.2 Strategy for Improving Rule Awareness and Self-Regulation Ability: "Keeping in Control"

The core is to help young people understand and internalize rules, and at the same time improve their ability to concentrate attention, manage emotions and behaviors^[11].

1. Promote "participatory" rule-making. While ensuring the bottom line of safety, hand over the right to formulate some living conventions (such as dormitory discipline) to campers, form consensus through group discussions and publicize them. Arrange campers to take turns as rule supervisors, transforming external rules into internal commitments, satisfying the need for autonomy and enhancing the willingness to abide by them.

2. Embed attention training sessions. Attention can be improved through practice. Before activities requiring fine operations (such as archery), short attention warm-up games (such as "do the opposite") can be conducted. During intervals between activity transitions, introduce a "one-minute quiet" mindfulness breathing exercise to help campers calm their emotions and regain attention. When guiding, coaches should use concise keywords (such as prompting "three-point fixation" when rock climbing) instead of long instructions to help campers maintain focus.

3. Provide "toolbox-style" emotion management methods. Emotion regulation is an acquirable skill. Activities such as "emotional weather forecast" can be carried out to encourage campers to identify and express their emotions every day. Teach

the “traffic light” emotion control method: red light (pause action, take deep breaths); yellow light (perceive feelings, think about consequences and alternative solutions); green light (choose the best action). Through situational discussions, guide campers to identify and restructure negative thoughts such as “catastrophizing” (e.g., changing “I completely failed” to “I found areas for improvement”), and cultivate a growth mindset.

4.3 Strategy for Shaping Sports Spirit and Team Cohesion: “Integrating Well”

It aims to guide young people to establish a correct view of competition and grow together in cooperation and respect.

1. Reshape a process-oriented view of success. By setting diverse awards such as “Best Progress Award” and “Team Collaboration Award”, affirm the value of effort, courage and cooperation. Set a fixed review session after team activities to guide discussions on team performance, areas for improvement and what has been learned from opponents, shifting the focus from victory or defeat to learning and growth.

2. Design highly interdependent collaborative tasks. Task cohesion arises from the mutual dependence of members to achieve common goals. Individual projects can be converted into a team scoring model (e.g., taking the minimum score of the team multiplied by the number of members as the total score) to encourage mutual assistance among members. Specifically design projects such as “Roman battlement construction” that can only be completed through close division of labor and cooperation to create real cooperative experiences^[12].

3. Integrate ritualized sports spirit education. Introduce an athlete’s oath session before competitive activities, emphasizing respect, striving and unity. After the game, force team members from both sides to line up and greet each other (shaking hands, high-fiving). By sharing model stories in sports history that reflect fair competition and tenacious struggle, make the connotation of sports spirit specific and vivid.

4.4 Strategy for Promoting Social Adaptation and Interpersonal Communication: “Getting Along Well”

The goal is to help young people quickly adapt to new collectives and master basic social and conflict resolution skills.

1. Provide “structured” pre-camp adaptation support. Make the process of getting familiar with the camp interesting, such as guiding groups to explore key places through “treasure hunting games”. Reasonably mix and form “camp family” groups, carry out activities and evaluations in these units during the camp period, and assign campers with strong adaptability to take on mutual assistance roles to create a supportive small environment.

2. Organize micro social skills workshops. Insert short and focused skill drills during the camp. The content includes: learning to use open-ended questions to start conversations and conduct active listening; practicing the “non-violent communication” model, expressing with “I-messages” (stating behaviors, feelings and needs) instead of accusation; learning the “conflict resolution ladder” steps: calm down—express respective feelings—jointly create multiple solutions—jointly select and implement solutions.

5. Conclusion

From the theoretical perspective of sports psychology, this study conducts an in-depth investigation and analysis on the practice of youth outdoor camp education at Fosun Tourism & Culture Mini-Camp. The study finds that although the camp has rich curriculum content and sophisticated hardware facilities, young people still generally face four major psychological challenges during participation: low willingness to participate in some activities, insufficient rule awareness and self-regulation ability, weakened sports spirit and excessive competition tendency, as well as difficulties in adapting to collective life and interpersonal frictions. These problems are rooted in the phased characteristics of young people’s physical and mental development and the insufficient attention paid to the psychological level in traditional camp education. To address these problems, this study systematically constructs a sports psychology optimization strategy system consisting of four modules.

The conclusion of this study is that the systematic and structured integration of sports psychology theories and technologies into youth outdoor camp education is an effective path to solve the current practical dilemmas and improve the quality of education. This is not only an optimization suggestion for the specific case of Fosun Tourism & Culture Mini-Camp, but also provides a reference theoretical framework and practical guide for the professional and scientific development of the entire industry^[13]. As a study based on qualitative observation and theoretical construction, this paper still has some limitations. It is

mainly based on the observation of the specific case of Fosun Tourism & Culture's Guilin Camp, and the generalizability of its conclusions needs to be further tested when extended to other camps with different positioning, types and regions. In short, the in-depth integration of sports psychology and youth outdoor camp education is a blue ocean full of potential. With the increasing social attention to young people's mental health and comprehensive quality, the research and practice in this interdisciplinary field will surely usher in a broader development prospect, making more outstanding contributions to cultivating a new generation capable of meeting future challenges.

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Research on the Practical Teaching Reform of “Deep Learning and Applications” Course Supported by Generative AI Technology

Tong Su*, Siyuan Bei

School of Computer Science and Artificial Intelligence, Shanghai, 201209, China

**Corresponding author: Tong Su*

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Abstract: With the rapid advancement of artificial intelligence, deep learning has become a core competency for students in computer science and related fields. However, the traditional practical teaching of “Deep Learning and Applications” faces significant challenges, including a steep learning curve, a notable gap between theoretical knowledge and practical application, insufficient computational resources, and a lack of personalized guidance, which collectively stifle student innovation and engagement. This paper explores a novel pedagogical reform for this course, centered on the integration of Generative AI (GenAI) technologies. We designed and implemented a new practical teaching framework that leverages GenAI as a multifaceted tool for code generation and debugging, synthetic data creation, personalized tutoring, and creative project development. Through a semester-long empirical study involving undergraduate students, we evaluated the effectiveness of this reformed curriculum. The study employed a mixed-methods approach, including pre- and post-course surveys, analysis of final project quality, and qualitative feedback. The results demonstrate that the GenAI-supported approach significantly enhances students’ practical skills, deepens their conceptual understanding, and boosts their problem-solving capabilities. Specifically, students showed marked improvements in model implementation efficiency, debugging proficiency, and the ability to undertake more complex and innovative projects. The integration of GenAI not only lowered the technical barrier to entry but also fostered a more dynamic and interactive learning environment, effectively bridging the theory-practice divide. This research provides valuable insights and a replicable model for reforming advanced technology courses, highlighting the transformative potential of Generative AI in modern higher education.

Keywords: Generative AI; Deep Learning Education; Practical Teaching Reform; Pedagogical Innovation; Artificial intelligence in Education

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1.Introduction

With the advent of digital, deep learning creates surges for CV, NLP, ASMs. Thus, the “deep learning and applications” course is now essential for all Computer Science, Data Science and AI majors. This course is to enable the students to understand neural network theory and how to design, implement and deploy DNN for real life problem. But the course’s pedagogy lags behind the field. Traditional teaching creates a gap between abstruse math and coding application: Students run into trouble with environment set up, complex model debugging, scarce data and limited computation resources^[1]. These difficulties

decrease a student's motivation, causing them to simply mimic textbook examples rather than developing creative thinking and problem solving skills necessary for real innovation. GenAI rises and provides a unique way for education transformation. Like GPT - 4 and Stable diffusion can benefit the learning process. This paper puts forward a reform of practical teaching of "Deep Learning and Applications" course, incorporating GenAI tools to improve the learning environment. How can GenAI Copilot help students by code generating, giving feedBack, creativity possible and personal learning? We want to lessen technical hurdles for students so they can concentrate on advanced ideas and innovating, developing AI folks who are talented and creative^[2]. Reformed model was introduced in this study, it's design, implementation and evaluation is provided along with an evidence of improved learning outcomes and providing a new paradigm for practical education in advance field.

2.Challenges in Traditional Deep Learning Pedagogy

Traditional deep learning practical teaching also brings many inherent obstacles and difficulties in student learning. A big issue is that students have a heavy cognitive load as they need to understand tricky math theories, learn Python, be good at TensorFlow or PyTorch, and grasp GPU hardware acceleration - it's a choppy learning experience. setting up a functional deep learning environment involves installing many libraries, drivers, and dependencies that can consume time and effort, before the actual learning can start And then deep learning stuff also requires a ton more coding, that's really challenging for beginner students^[3]. Debugging neural networks isn't like normal software—errors are subtle and make the program fail quietly, so students have a tough time spotting problems with its architecture, hyperparameters, or preprocessed data. And it can be frustrating and helpless, especially when the instructor is late with feedback. There's another big problem: the "dataset dilemma." High-performers in DL need big, well-formatted datasets, which can be tough for students who have privacy, storage, or collection problems. Standard datasets like MNIST or CIFAR-10, though good for novices, lack actual world complexity, making projects less relevant and skills harder to transfer to real industry problems. The "one size fits all" model stifles creativity and dismisses different student interests. If we give all the students the same project then there is a chance which can lead to rote learning and plagiarism and will be less scope for the individual student to explore the niche area which might interest them. This kind of standardization fails to raise the innovative mindset and adaptability needed for AI jobs.

3.The Role of Generative AI in Reshaping Practical Teaching

The integration of Generative AI into the "Deep Learning and Applications" curriculum offers a powerful antidote to the challenges plaguing traditional pedagogy. GenAI can be strategically employed as a versatile educational tool that redefines the student learning experience by providing scaffolding, personalization, and creative empowerment. Firstly, GenAI, particularly large language models (LLMs), can serve as intelligent coding assistants. Students can use these tools to generate boilerplate code for data loading, model architecture, and training loops, which dramatically lowers the initial barrier to entry and accelerates the development process. Instead of getting bogged down by syntax and library-specific implementation details, students can focus their cognitive energy on understanding the core logic and high-level design of their models. When encountering bugs, they can leverage AI to explain error messages, suggest potential fixes, and refactor code for better clarity and efficiency. This transforms the frustrating process of debugging into a valuable, interactive learning opportunity. Secondly, GenAI provides a solution to the dataset scarcity problem^[4]. Generative models like Generative Adversarial Networks or Variational Autoencoders can be used to create high-quality synthetic data. This not only provides students with ample data for training their models but also serves as a practical learning module in itself, allowing them to explore concepts of data distribution. Students can learn to generate custom datasets tailored to specific, imaginative project ideas, freeing them from the constraints of pre-existing, and often overused, public datasets^[5]. The comparison outlined in Table 1 highlights the transformative shift from a static, resource-limited model to a dynamic, AI-augmented one.

Table 1: Comparison of Traditional vs. Generative AI-Supported Practical Tasks

Feature Area	Traditional Practical Task	Generative AI-Supported Practical Task
Project Scaffolding	Manual code writing from scratch; high initial friction.	AI-assisted code generation; rapid prototyping and iteration.

Feature Area	Traditional Practical Task	Generative AI-Supported Practical Task
Dataset Availability	Limited to standard, pre-existing academic datasets.	Ability to generate custom, diverse synthetic datasets on-demand.
Code Debugging	Time-consuming, reliant on instructor or peer support.	Instant, interactive AI-powered explanations and suggestions.
Personalized Feedback	Delayed and generalized feedback from instructors.	Real-time, context-specific tutoring and conceptual clarification.
Project Innovation	Constrained by technical complexity and available resources.	Enabled by AI tools to explore more creative and ambitious ideas.
Learning Curve	Steep and often frustrating for novice learners.	Smoothed by AI assistance, allowing focus on higher-level concepts.

This table clearly illustrates how GenAI acts as a catalyst, transforming previously challenging aspects of the learning process into opportunities for deeper engagement and understanding. It shifts the instructor's role from a primary troubleshooter to a facilitator of higher-order thinking, guiding students as they use AI tools to explore more ambitious and personalized projects. By automating mundane tasks and providing on-demand support, GenAI empowers students to become more autonomous and confident learners, capable of tackling complex problems with a blend of theoretical knowledge and advanced practical skills. This new paradigm fosters an environment where curiosity and creativity are not just encouraged but are actively supported by powerful technological aids^[6].

4.Design and Implementation of the Reformed Curriculum

Based on the potential of Generative AI to mitigate the challenges of traditional pedagogy, we designed and implemented a reformed practical curriculum for the “Deep Learning and Applications” course. The central principle of this reform was to embed GenAI tools seamlessly into the existing learning structure, not as a replacement for fundamental understanding, but as a powerful enabler of it^[7]. The implementation was rolled out over a 16-week semester for a cohort of 85 undergraduate students. The curriculum was redesigned into a series of project-based modules, each tackling a core area of deep learning while integrating specific GenAI applications. For the foundational modules on topics like Convolutional Neural Networks and Recurrent Neural Networks, students were introduced to AI-powered coding assistants such as GitHub Copilot. They were trained not just on how to use these tools to generate code, but more importantly, on how to critically evaluate, debug, and refine the AI-generated outputs. This approach aimed to develop their skills in prompt engineering and AI-assisted problem-solving. For more advanced modules, the integration of GenAI became more profound. For instance, in the module on image processing, instead of merely using standard datasets, students were tasked with using text-to-image models like Stable Diffusion to generate a unique dataset of images based on a creative theme^[8]. They then had to train a CNN model to classify these AI-generated images, providing them with an end-to-end understanding of both generative and discriminative models. The detailed structure of this reformed curriculum is presented in Table 2.

Table 2: Structure of the Reformed ‘Deep Learning and Applications’ Curriculum

Module No.	Topic	Learning Objectives	Practical Activity with GenAI Integration	GenAI Tools Used
1-3	Foundations & Neural Networks	Understand basics, build simple networks.	Use AI assistant to generate boilerplate code for data loading and model layers; debug syntax errors.	GPT-4 (via API), GitHub Copilot
4-6	Convolutional Neural Networks (CNNs)	Master CNNs for image classification.	Generate a custom synthetic image dataset using a text-to-image model; train a classifier on this data.	Stable Diffusion, Midjourney
7-9	Recurrent Neural Networks (RNNs) & NLP	Understand sequence modeling for text.	Use an LLM to generate diverse text prompts; build an RNN-based sentiment analyzer for the generated text.	GPT-4 API

Module No.	Topic	Learning Objectives	Practical Activity with GenAI Integration	GenAI Tools Used
10-12	Generative Adversarial Networks (GANs)	Grasp the theory and application of GANs.	Fine-tune a pre-trained GAN model on a specific domain; analyze and critique the quality of generated outputs.	PyTorch, Pre-trained StyleGAN models
13-16	Final Capstone Project	Synthesize knowledge to solve a complex problem.	Propose and develop a novel application leveraging one or more GenAI technologies.	Student's choice of relevant AI tools and APIs

This modular structure ensured a progressive learning journey. Early modules focused on using GenAI for assistance and efficiency, gradually transitioning to more advanced modules where GenAI itself was the subject of study and the core component of the project. The final capstone project provided students with the ultimate freedom to explore their interests, challenging them to develop a novel application that showcased their mastery of both deep learning principles and GenAI tools. Throughout the semester, traditional lectures were supplemented with hands-on workshops focused on the ethical use of AI, prompt engineering techniques, and the critical assessment of AI-generated content. This holistic approach ensured that students developed not only technical proficiency but also a responsible and informed perspective on the capabilities and limitations of generative AI, preparing them to be conscientious innovators in the field.

5.Evaluation of Teaching Outcomes

To quantitatively and qualitatively assess the effectiveness of the generative AI-integrated teaching reform, we conducted a comprehensive evaluation throughout the semester. The methodology involved a multi-faceted approach, including pre- and post-course surveys based on a 5-point Likert scale to measure students' self-assessed skills and confidence, a detailed analysis and comparison of the final capstone projects against those from a previous cohort taught using traditional methods, and the collection of anecdotal feedback through focus group discussions. The pre-course survey established a baseline, confirming that most students entered the course with a theoretical understanding of AI but limited practical experience and low confidence in their ability to build and debug complex models. The post-course survey results, as summarized in Table 3, revealed a statistically significant improvement across all measured skill dimensions. Students reported a substantial increase in their confidence and efficiency in implementing models, debugging code, and creatively applying deep learning concepts to novel problems^[9]. The most notable improvements were observed in "Creative Problem-Solving" and "Project Implementation Speed," which directly correlate with the affordances of the GenAI tools that students used to brainstorm ideas and accelerate their development workflows.

Table 3: Pre- and Post-Reform Student Skill Self-Assessment (Scale 1-5, n=85)

Skill Dimension	Pre-Reform Mean Score	Post-Reform Mean Score	Percentage Change
Conceptual Understanding	3.1	4.6	+48.4%
Model Implementation Proficiency	2.2	4.4	+100.0%
Code Debugging Efficiency	1.9	4.1	+115.8%
Creative Problem-Solving	2.5	4.7	+88.0%
Project Implementation Speed	2.1	4.5	+114.3%

The second source of empirical data was from comparing capstone projects. The projects in the experimental group were assessed by instructors on a rubric that evaluated how much technical depth was put into it, was it innovative and complex? In Table 4 it can be seen that the reformed curriculum has gotten the highest scores for every category especially for innovation: Traditional curriculum projects were commonly made with a standard implementation on a common dataset, but genai supported projects showed incredible creativity and ambition^[10]. The examples comprised apps employing an LLM to create animation scripts and systems for synthetic medical images augmentation which adds to the training data of medical disease detection systems. They were a bit more technologically advanced and they dived into the world of what the real

world impact of AI was. In terms of students' focus group feedback, they agreed with these statements, as well as stating that AI tools made it feel like they really were a developer, able to mess around and try things, making for a good learning experience.

Table 4: Analysis of Final Project Complexity and Innovation Scores (out of 10)

Evaluation Metric	Control Group (Traditional, n=78)	Experimental Group (GenAI-Reformed, n=85)	Improvement
Technical Depth	6.2	8.5	+37.1%
Innovation & Creativity	4.5	8.9	+97.8%
Project Complexity	5.8	8.2	+41.4%
Overall Score	5.5	8.5	+54.5%

6. Conclusion

This research has systematically investigated the integration of Generative AI as a transformative tool in the practical teaching reform of the “Deep Learning and Applications” course. The findings unequivocally demonstrate that this novel pedagogical approach yields substantial benefits, effectively addressing the persistent challenges of traditional methods. By leveraging GenAI for code generation, synthetic data creation, and personalized support, we have successfully lowered the steep technical barriers that often discourage students, allowing them to engage more deeply with core conceptual material. The empirical results, drawn from student self-assessments and expert evaluation of capstone projects, provide compelling evidence of improved learning outcomes. Students in the reformed curriculum not only achieved greater technical proficiency and debugging efficiency but also demonstrated a remarkable enhancement in their capacity for creative problem-solving and innovation. The freedom to rapidly prototype ideas and explore more ambitious projects fostered a more dynamic, engaging, and motivating learning environment, effectively bridging the gap between abstract theory and practical, real-world application. However, the successful implementation of such a curriculum is not without its challenges. It requires a pedagogical shift where instructors evolve into facilitators who guide students in the critical and ethical use of AI tools, rather than simply transmitting information. There is a tangible risk that students might develop an over-reliance on AI, potentially neglecting the development of fundamental coding skills. Therefore, future iterations of the curriculum must place an even stronger emphasis on teaching students to critically analyze, validate, and refine AI-generated outputs, ensuring that these tools serve as a scaffold for learning, not a crutch. Furthermore, the ethical dimensions of generative AI, including issues of bias, plagiarism, and misinformation, must be woven deeply into the educational fabric. Future research should explore the long-term impact of this pedagogical model on student career trajectories and investigate its applicability across other complex STEM disciplines. In conclusion, the strategic integration of Generative AI in deep learning education represents a significant step forward, promising to cultivate a new generation of AI professionals who are not only technically adept but also creatively agile and ethically conscious.

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Research on the Precise Strategies for Employment and Entrepreneurship Services for College

Jingjing Luo*

Nantong University Xinglin College, Jiangsu Nantong, 226236, China

*Corresponding author: Jingjing Luo, Ljflying2024@163.com

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Abstract: With the deepening popularization of higher education, the number of college graduates increases year by year, and their employment and entrepreneurship needs present unprecedented characteristics of diversification and personalization. Traditional standardized and large-scale service models face severe challenges. Based on the concept of precision services, this paper systematically explores innovative paths for the employment and entrepreneurship services of college graduates. The article first analyzes the core dilemmas currently faced by graduates in the job market and entrepreneurial environment. It then constructs a precision service framework covering multiple dimensions such as precise identification, intelligent matching, curriculum restructuring, collaborative education, and effectiveness evaluation. Finally, it proposes a series of actionable implementation strategies aimed at enhancing the targeting and effectiveness of employment guidance services through data-driven and personalized provision, ultimately promoting fuller and higher-quality employment and entrepreneurship for graduates.

Keywords: College Graduates; Employment and Entrepreneurship Services; Precision Strategy; Personalized Guidance

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1.Introduction

College graduates, as an important national human resource, have their employment and entrepreneurship situation directly impacting the quality of higher education and social development stability^[1]. In recent years, the scale of higher education in China has continued to expand, with the number of graduates exceeding ten million, reaching a historical peak particularly for the class of 2023. However, against the backdrop of complex and changing domestic and international economic environments and accelerated industrial restructuring, the job market exhibits a structural contradiction where “difficulty finding jobs” coexists with “difficulty recruiting,” reflecting a significant mismatch between talent supply and market demand. Simultaneously, the graduate population, primarily composed of the “post-00s generation,” shows more diverse career attitudes and employment choices. Some prefer stable positions within government-affiliated institutions, others favor emerging fields or self-employment, and still others focus on academic advancement, demonstrating highly heterogeneous demand characteristics^[2]. This trend towards personalization and diversification makes it difficult for traditional extensive, standardized employment and entrepreneurship service models to adapt to new requirements, and the contradiction between generalized service provision and refined student needs is becoming increasingly prominent^[3].

In this context, promoting the transformation of employment and entrepreneurship services towards precision and intelligence

is imperative. Precision services, supported by data and centered on students, optimize resource allocation and achieve efficient person-job matching through precise identification of individual characteristics and market demands^[4]. This is not only a key path to alleviating structural employment contradictions but also an important measure to enhance the adaptability of university talent cultivation and promote the connotative development of higher education. Based on this, this study intends to systematically analyze the practical problems currently faced by college graduates in employment and entrepreneurship, construct a precision service framework, and propose targeted implementation strategies, hoping to provide reference for improving the quality and efficiency of university employment work^[5].

2.The Realistic Dilemmas of Employment and Entrepreneurship for College Graduates and the Necessity of Precision Services

2.1 In-depth Analysis of Realistic Challenges

The difficulties confronting college graduates in employment and entrepreneurship are multi-level and systemic, primarily manifested in the following aspects:

The structural imbalance between talent supply and market demand has become increasingly pronounced. Higher education maintains relatively stable disciplinary structures and curricular systems due to inherent program cycles, while emerging industries and new business models evolve rapidly. This creates a challenge for universities in promptly addressing the urgent demand for core technical talents and interdisciplinary professionals in cutting-edge fields such as artificial intelligence and big data. Meanwhile, graduates from certain traditional disciplines encounter limited job opportunities due to market saturation. Furthermore, a significant gap exists between graduate competencies and workplace requirements. Many students possess theoretical knowledge but lack practical skills, innovative thinking, teamwork abilities, and other essential soft skills, making it difficult to adapt quickly to actual job demands.

The conflict between standardized service models and individualized graduate needs has become increasingly acute. Current employment and entrepreneurship services in many universities demonstrate considerable path dependency, predominantly relying on large-scale job fairs and generic lectures—a “one-size-fits-all” approach. While achieving broad coverage, these models fail to address the diverse needs of students from different academic backgrounds and career orientations. For instance, the guidance and resources required by students pursuing grassroots employment substantially differ from those needed by candidates targeting multinational corporations. Entrepreneurship education commonly prioritizes theoretical knowledge over practical application and breadth over depth. Although entrepreneurial activities appear diverse, the general lack of targeted incubation guidance and sustained support mechanisms undermines their practical effectiveness.

Fragmented information and inadequate decision-making support significantly hamper service efficacy. Graduates frequently struggle to filter through overwhelming amounts of disjointed recruitment information and policy announcements, where information overload paradoxically increases decision-making costs. Moreover, the absence of efficient information-sharing mechanisms among universities, employers, and government departments creates significant “information silos.” This impedes universities’ ability to stay current with industry trends and precise corporate needs, while simultaneously preventing companies from gaining accurate insights into institutional talent development. Additionally, the lack of effective integration and analysis of employment service data within universities results in management decisions based predominantly on experiential judgment. This approach hinders scientific evaluation of service outcomes and trend forecasting, consequently limiting the foresight of optimization strategies and policy adjustments.

2.2 The Intrinsic Value and Core Concepts of Precision Service

Facing the above challenges, promoting employment and entrepreneurship services towards precision is not only an upgrade of technical means but also a profound transformation of service philosophy. Its core value lies in shifting from pursuing “scale effects” to “scope effects,” and from a “management-oriented” to a “service-oriented” approach.

Precision services first help optimize resource allocation. By accurately identifying student needs, limited resources can be concentrated on the groups most in need of assistance (e.g., those with employment difficulties, strong entrepreneurial intentions) and the most critical links (e.g., job recommendations, personalized counseling), thereby improving service efficiency. Secondly, it can significantly enhance students’ sense of fulfillment and success. Tailored guidance helps students

clarify their positioning and improve their abilities. The experience of “being seen and supported” helps stimulate endogenous motivation, thereby improving the effectiveness of employment and entrepreneurship. Finally, this model promotes the formation of a linkage feedback mechanism encompassing “student recruitment - cultivation - employment.” Data on employment quality and career development accumulated during the service process provide a basis for decision-making regarding major setting and curriculum reform, continuously enhancing the social adaptability of talent cultivation.

The core concepts of precision services can be summarized as “data-driven, individual care, whole-process tracking, and dynamic optimization.” It emphasizes using information technology to achieve precise profiling and intelligent management, using personalized support to respond to students’ unique needs, using whole-process services to achieve continuous empowerment, and using continuous evaluation to drive strategy iteration, maintaining the system’s vitality.

3. Framework for Constructing a Precision Service System for Graduate Employment and Entrepreneurship

Constructing a scientific, efficient, and sustainable precision service system requires top-level design and overall planning from a systems theory perspective. This system should be a multi-level, multi-stakeholder, online-offline integrated organic whole. Its core architecture can consist of the following five interconnected and mutually supportive layers:

Data Perception and Profiling Layer (Foundation Layer): This is the cornerstone of the entire precision service system. The goal is to achieve comprehensive, dynamic data collection and precise characterization of individual students, market demands, and service processes. Specifically, for individual students, it is necessary to integrate comprehensive data from their academic careers, including but not limited to: academic performance across subjects, records and evaluations of internship and practical experiences, research achievements and competition awards, performance in club activities and social work, acquisition of vocational skill certificates, psychological assessment results, vocational tendency assessment data, and even behavioral data (e.g., from campus card usage) indirectly reflecting lifestyle patterns and potential difficulties. Using big data technologies and algorithmic models, these multi-source heterogeneous data are fused and analyzed to build a dynamically updated, multi-dimensional “digital profile” for each student, clearly presenting their knowledge structure, skills and strengths, interests and preferences, personality traits, career values, and potential development needs. For market demand, it is necessary to establish enterprise and position databases, continuously collect and structurally process recruitment information from job boards, partner enterprises, government human resources departments, and industry associations, along with industry trend reports and industrial policy dynamics, forming a systematic understanding of the labor market demand side. For the service process, data on student participation in various employment and entrepreneurship activities (e.g., lectures, counseling, job fairs, training) such as frequency, duration, and feedback evaluations need to be recorded.

Intelligent Intervention and Push Layer (Core Layer): Based on precise profiling, this layer is responsible for providing personalized service interventions and resource matching. It is the direct embodiment of precision services. First, there is algorithm-based intelligent matching and recommendation. The system can automatically match students’ personal profiles with job profiles and entrepreneurial resource profiles, achieving precise “person-position” recommendations, “person-entrepreneurship project” connections, and “person-training course” pushes, significantly reducing students’ information search costs and improving matching efficiency. Secondly, there is the generation of personalized service plans. The system can assist employment guidance teachers in generating customized “one plan per student” action plan suggestions for students with different need types (e.g., those pursuing postgraduate studies, civil service exams, jobs in renowned companies, self-employment, etc.), clarifying goals, tasks, required resources, and action steps at different stages. Finally, there is proactive service outreach. Changing from the past passive mode of waiting for students to seek help, the system actively pushes potentially interesting recruitment information, policy interpretations, lecture notices, or counseling appointment reminders to students through platform messages, SMS, email, etc., realizing a shift from “people seeking services” to “services finding people.”

Resource Integration and Supply Layer (Content Layer): Precise intervention requires high-quality, abundant service resources as support. This layer is responsible for integrating, optimizing, and modularizing various internal and external employment and entrepreneurship resources, forming an easily accessible and combinable “service resource pool.” In terms

of curriculum resources, break away from the traditional fixed-credit course model and develop a series of micro-courses, workshops, online open courses (MOOCs), and other modular learning resources covering career planning, resume writing, interview skills, workplace soft skills, basic entrepreneurship knowledge, business plan writing, financing pitches, etc. Students can choose and combine these resources independently based on their profile and needs, like shopping in a “supermarket.” In terms of practical resources, vigorously expand and construct high-quality internship and practice bases, innovation and entrepreneurship incubation spaces, and cooperate with enterprises to develop virtual simulation internship projects, entrepreneurial sandbox simulations, etc., providing students with low-cost, low-risk opportunities for practice in real-world scenarios. In terms of mentor resources, establish a diversified mentor database composed of internal professional teachers, career counselors, corporate executives, technical experts, successful alumni, venture investors, etc., to provide students with multi-faceted personalized consultation and guidance.

Multi-party Collaboration and Ecosystem Layer (Guarantee Layer): Precision services are not the sole responsibility of the university’s employment department. It is necessary to break down organizational barriers and build a collaborative education ecosystem with internal and external linkages. Internal collaboration requires completely breaking down the barriers between the Career Guidance Center, Student Affairs Office, Academic Affairs Office, Graduate School, various academic departments, and the Innovation and Entrepreneurship College, establishing regular consultation, information sharing, and collaborative working mechanisms to form a joint force in education. For example, integrate employment and entrepreneurship education into the entire process of professional teaching, encouraging subject teachers to organically incorporate professional literacy and industry frontier knowledge into their teaching. External collaboration involves actively strengthening strategic cooperation with local government human resources and social security departments, industrial parks, industry associations, and leading enterprises to jointly build talent co-cultivation platforms and resource platforms. Actively introduce external resources such as policy subsidies, venture capital funds, and low-interest loans to provide tangible support for student employment and entrepreneurship.

Evaluation, Feedback, and Optimization Layer (Improvement Layer): A good system must possess the ability for self-evaluation and self-improvement. This layer aims to establish a set of data-based service effectiveness monitoring and continuous improvement mechanisms. By tracking and recording key behavioral indicators (e.g., number of resumes submitted, interview participation rate, job offer reception, entrepreneurial project progress) and ultimate outcome indicators (e.g., employment rate, employment satisfaction, starting salary, job-major alignment rate, entrepreneurial survival rate) after students receive services, conduct comprehensive quantitative and qualitative evaluations of the effectiveness of various service strategies and activities. Through data analysis, weak links and successful experiences in services can be identified, providing a scientific basis for adjusting resource allocation, optimizing service processes, and improving working methods, achieving closed-loop management of “evaluation-feedback-optimization.” This ensures that the precision service system can dynamically adapt to changes in the internal and external environment, maintaining its advanced nature and effectiveness.

4.Key Strategies for Implementing Precision Services

To put the constructed precision service system into practice, a series of specific and feasible strategies are needed for support. Universities should promote the following key measures step by step and with focus, according to their actual situation

4.1 Strengthen Technology Empowerment, Consolidate the Data Foundation, and Build a Solid Technical Base for Precision Services

Technology is the key engine for achieving precision. Universities should increase investment in the construction of smart employment and entrepreneurship platforms, creating an intelligent integrated service platform that combines data collection, storage, analysis, management, and service application. This platform should possess the following core functions: First, strong data middleware capabilities, able to securely and compliantly integrate data from multiple business systems such as educational administration, student affairs, and campus card systems, and capable of data cleansing and label management. Second, advanced user profiling and recommendation engines, able to use algorithms like machine learning for deep understanding of students and positions and intelligent matching. Third, convenient online service functions, supporting

online consultation, video interviews, electronic signing, activity registration, progress queries, etc. Fourth, intuitive data visualization and decision support dashboards, providing real-time, intuitive data insights for administrators and instructors. While promoting technology application, great importance must be attached to data ethics and privacy protection, establishing strict data management and usage norms to ensure the security of students' personal information.

4.2 Promote Faculty Transformation, Enhance Professional Competence, and Build a Team of Expert Instructors Competent in Precision Guidance

No matter how advanced the technology, it requires people to operate and use it. Precision services place higher demands on the capabilities of the employment and entrepreneurship work team. Systematic training for existing career guidance instructors must be strengthened, enabling them not only to master traditional counseling skills but also to understand basic methods of data analysis, know how to use career assessment tools, and provide personalized diagnosis and advice based on data insights. Instructors should be encouraged to leave the campus and undertake internships in enterprises to gain an in-depth understanding of industry dynamics and employment standards, enhancing the practicality and targeting of their guidance. Simultaneously, external mentor resources should be vigorously expanded by actively inviting experienced corporate HR professionals, industry elites, successful entrepreneurs, investors, etc., to serve as "career mentors" or "entrepreneurship mentors" for students, forming a high-level guidance team combining internal and external, full-time and part-time members, and establishing standardized mechanisms for mentor appointment, training, incentive, and evaluation.

4.3 Deepen Industry-Education Integration, Innovate Collaboration Mechanisms, and Bridge the "Last Mile" Between Talent Cultivation and Market Demand

The ultimate goal of precision services is to promote graduates to meet social needs with higher quality. Therefore, deep integration into the industrial ecosystem is crucial. Universities should proactively establish strategic partnerships with key regional industries and leading enterprises to jointly carry out "order-based" cultivation, co-build modern industry colleges, and set up customized talent programs. Introduce real enterprise projects, cases, and technical standards into the classroom and graduation design sessions, promote "Project-Based Learning" (PBL), and enhance students' comprehensive abilities through solving practical problems. Establish an "internship-employment" linkage mechanism, organically combining graduation internships with job hunting, and improve the conversion rate of internships. Regularly invite enterprise experts to participate in the revision of talent cultivation plans and course design demonstrations, ensuring the foresight and adaptability of talent cultivation.

4.4 Optimize Evaluation Mechanisms, Establish a Quality Orientation, and Guide Employment and Entrepreneurship Work Towards Connotative Development

The "baton" determines the direction of work. To effectively promote precision services, the traditional evaluation system for employment work must be reformed, abandoning the quantity-oriented approach that solely pursues the "initial employment rate." A comprehensive set of quality evaluation indicators for employment and entrepreneurship should be gradually established, incorporating metrics that reflect development quality, such as "degree of job-major relatedness," "employer satisfaction," "graduate starting salary and medium-to-long-term salary growth," "career development prospects," and "entrepreneurial project growth potential and social value." The implementation status of precision services, student satisfaction, and the actual results generated through services (e.g., the effectiveness of assisting disadvantaged groups, the success rate of entrepreneurial project incubation) should be used as important bases for evaluating the performance of departments and related units, thereby guiding the focus of various tasks to truly shift towards improving service quality and effectiveness, and continuously promoting the high-quality development of employment and entrepreneurship work for college graduates.

5. Conclusion

In summary, promoting the precision of employment and entrepreneurship services for college graduates is a strategic choice in the new development stage to cope with the severe employment situation and meet the diverse development needs of students. It is a concrete embodiment of implementing the "people-centered" development philosophy in the field of higher education and an important point for enhancing university governance capacity and modernization level. This is

a systematic project involving conceptual renewal, technology application, process reengineering, organizational change, and ecological restructuring, which cannot be achieved overnight. It requires university administrators to have forward-looking strategic vision and firm reform determination, demands the transformation of capabilities and upgrading of roles for the employment work team, and calls for consensus and synergy in collaborative education throughout the university. In the future, universities need to boldly explore in practice, continuously improve the technical platform, content system, operational mechanism, and evaluation standards of precision services, while actively seeking support from the government, enterprises, and all sectors of society to jointly build a new, vibrant, efficient, and sustainable ecosystem for employment and entrepreneurship services. Only in this way can we truly empower every graduate's career launch and life success, and provide a more solid talent support and intellectual guarantee for comprehensively building a modern socialist country.

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Construction of an Evaluation Index System for the “Three-Wide Education” Mentor Team

Hao Gu*

School of Management, Xi ‘an Polytechnic University, Institute of Population and Social Policy, Xi ‘an Polytechnic University Xi’an, 710600, China

*Corresponding author: Hao Gu, guhao2023@163.com

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Abstract: This study focuses on the construction of an evaluation index system for the “Three-Wide Education” tutor team, aiming to address the current lack of systematic, scientific, and quantitative standards in evaluating university tutor teams. Through literature analysis and policy review, the research team established an evaluation system comprising 3 first-level indicators, 13 second-level indicators, and 24 third-level indicators, covering the three dimensions of input evaluation, process evaluation, and output evaluation. The Analytic Hierarchy Process was employed to determine indicator weights, with results showing that output evaluation (44.9%) and process evaluation (41.7%) dominate the system, highlighting the central role of educational effectiveness and implementation process. Among specific indicators, competency development, employment outcomes, and research growth guidance carry the highest weights, while participation in academic competitions and social practices, employment guidance services, and tutor incentives emerge as key evaluation points. The study demonstrates that this system emphasizes substantive outcomes and core indicators, providing a quantitative basis for the scientific evaluation and continuous improvement of university tutor teams, reflecting the “student development-centered” educational philosophy.

Keywords: Three-Wide Education; Tutor Team; Evaluation System

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1.Introduction

What kind of people to cultivate, how to cultivate them, and for whom to cultivate them are the three questions that ideological and political education in Chinese universities must always confront directly. Against this backdrop, all universities in Shaanxi Province have been actively carrying out the practical work of “all-round education for all”, and the “All-round Education Mentor Group” is an important measure taken by Xi ‘an Polytechnic University to implement the requirements of the opinions issued by the Central Committee of the Communist Party of China and The State Council and to carry out the practical work of “all-round Education for All”. However, in the practical process, universities have not yet established a systematic and scientific evaluation system for the “all-round Education mentor group”. The current assessment mostly remains at an empirical and fragmented level, lacking unified and standardized measurement standards. Meanwhile, the current evaluation indicators are highly subjective and mostly rely on qualitative descriptions and impression evaluations, making it difficult to conduct objective and precise quantitative assessments of the effectiveness of educational work. This situation where evaluation is lacking and subjective coexists not only affects the accurate judgment of educational

effectiveness but also restricts the continuous improvement and optimization of the mentor team's work, making it difficult to meet the high standards of moral education and talent cultivation in the new era.

2. Literature Review

By reviewing relevant literature, “all-round education for all” has attracted extensive attention and research from many scholars as an important topic in the current field of higher education. Among them, “mentorship system” is a high-frequency keyword in terms of the main body of education^[1]. Different universities, colleges and majors have carried out a series of practices around the “all-round education mentorship system”^[2-3]. For instance, the practice of the “six-in-one” undergraduate full-process mentorship education model implemented by Xi'an Polytechnic University^[4]; The Practice of the “1 class, 4 Mentors, 3 Collaborations, 4 Supports” four-in-one Undergraduate mentorship Education Model of the College of Biochemical Engineering, Beijing Union University^[5] The practice of the “Tengyue” mentor team model implemented by Shanghai University of Traditional Chinese Medicine, which covers multiple disciplines of traditional Chinese medicine, attracts and recruits multiple talents in the medical field, and conducts cross-border collaborative education^[6].

Based on existing research, current studies on the evaluation of the “all-round education” mentor group focus on different mentor roles and educational collaboration models, such as the role of postgraduate mentors in “moral education and talent cultivation” from the perspective of “all-round education”^[7-8], and the role of political theory learning mentors in the construction of the “all-round education” system^[9-10]. Exploration of the Collaborative Education Path between Professional Mentors and Counselors^[11-12] However, some problems have emerged in the practice of the mentorship system. For instance, the positioning of the “mentorship teams” in various universities is uncertain, and the detailed implementation rules of the mentorship teams are not standardized or specific^[13]. Research on the evaluation index system of the “all-round education” mentorship teams is still relatively scarce. When Xi'an Polytechnic University carried out the “All-Round Education Mentor Team” work, it set up quantitative assessment indicators from three aspects: student evaluation, the implementation of mentor team activities, and the educational effectiveness of the mentor team. However, the evaluation basis was highly subjective.

3. Evaluation index

After multiple rounds of revision and improvement, in combination with the “Implementation Measures for the ‘All-Round Education Mentor Group’ of Xi'an Polytechnic University”, the “Comprehensive Reform Pilot Construction Standards for ‘All-round Education’ in Regular Institutions of Higher Learning (Trial)” issued by the Ministry of Education (for details, see the appendix), and other policy documents as well as relevant literature, The research team ultimately established an evaluation index system for the “All-round Education Mentor Group”, which includes 3 first-level indicators, 13 second-level indicators, and 24 third-level indicators (see Table 1).

Table 1 Evaluation Index System of the All-round Education Mentor Team

First-level Indicators	Second-level Indicators	Third-level Indicators
A Input Evaluation	A1 Tutor Team Development	A11 Number of Tutors
		A12 Types of Tutors
	A2 External Cooperation Resources	A21 Collaborative Education through Home-School-Community Partnerships
	A3 Incentive Mechanism	A31 Tutor Incentives
B Process Evaluation	B1 Ideological and Political Education	B11 Conducting Various Thematic Education Activities
	B2 Research and Academic Growth Guidance	B21 Professional Knowledge Guidance
		B22 Research Project Guidance
	B3 Innovation, Entrepreneurship, and Competition Guidance	B31 Guidance for Academic Competitions, Innovation, and Entrepreneurship Practices
		B32 Organizing Innovation and Entrepreneurship Lectures, Forums, and Simulation Practices
	B4 Mental Health Education	B41 Conducting Mental Health Education Activities
	B5 Employment Guidance	B51 Conducting Vocational Aptitude Tests
		B52 Providing Employment Guidance Services

First-level Indicators	Second-level Indicators	Third-level Indicators
C Output Evaluation	C1 Students' Comprehensive Evaluation of the Tutor Team	C11 Students' Awareness of the Tutor Team
		C12 Students' Satisfaction with the Tutor Team
		C13 Alumni Evaluation of the Tutor Team
	C2 Ideological and Political Development	C21 Moral Education Level
	C3 Academic Level	C31 Participation in Tutor Research Projects
		C32 Publication of Theses and Patents
		C33 Student Academic Performance / Grades
	C4 Competency Development	C41 Participation in Academic Competitions and Social Practices
		C42 Participation in Cultural and Sports Activities
	C5 Employment Outcomes	C51 Graduate Employment Rate
		C52 Graduate Civil Service Examination Success Rate
		C53 Graduate Postgraduate Entrance Examination Success Rate

4.Results

According to the indicator weight analysis results, among the three first-level indicators of the tutor team construction evaluation system, the weight of output evaluation is the highest, reaching 44.9%. Process evaluation follows closely at 41.7%. Together, they account for over 85% of the total, indicating that the quality of output outcomes and the effectiveness of process implementation are regarded by experts as the most critical assessment dimensions in the tutor team construction evaluation system, jointly forming the core content of the evaluation framework. In contrast, the weight of input evaluation is 13.4%. Although relatively low, it still plays a crucial foundational role as a basic support condition in areas such as tutor team development, external cooperation resources, and incentive mechanisms.

Looking at the global weight distribution of the second-level indicators, Competency Development (16.5%), Employment Outcomes (11.8%), and Research and Academic Growth Guidance (11.1%) rank in the top three. Combined, these three indicators account for nearly 40%, fully demonstrating the high priority this evaluation system places on enhancing students' comprehensive qualities, focusing on employment results, and cultivating research capabilities. This reflects the educational philosophy in modern higher education that emphasizes the holistic development of students. In comparison, indicators such as Students' Comprehensive Evaluation of the Tutor Team (6.2%), Ideological and Political Development (3.1%), and External Cooperation Resources (1.7%) have relatively lower weights, suggesting their perceived importance within the current evaluation system is more limited, though they still serve as essential components of the framework, playing unique supplementary roles.

A deeper analysis of the weight distribution of the third-level indicators reveals that Participation in Academic Competitions and Social Practices holds the top position with a global weight of 12.7%. This highlights the critical role of practical education in the talent cultivation process. Providing Employment Guidance Services (7.8%) and Tutor Incentives (7.5%) rank second and third, respectively, indicating the importance of employment service quality and tutor motivation at the implementation level. It is noteworthy that within the Research and Academic Growth Guidance dimension, the weight for Research Project Guidance (7.1%) is significantly higher than that for Professional Knowledge Guidance (4.1%), reflecting the evaluation system's greater emphasis on cultivating students' practical research abilities.

In contrast, indicators such as Students' Awareness of the Tutor Team (1.1%), Conducting Vocational Aptitude Tests (2.8%), and Number of Tutors (1.9%) carry lower weights, suggesting their relative influence on the overall evaluation is more limited. This weight distribution characteristic embodies the design philosophy of the evaluation system constructed in this project, which focuses on substantive outcomes and highlights core indicators. From the perspective of the indicator system's hierarchical structure, Employment Guidance (10.6%) and Innovation and Entrepreneurship Guidance (9.6%) within Process Evaluation carry high weights, demonstrating the importance placed on student career development and innovation capability cultivation. At the Output Evaluation level, the prominent weight of Competency Development further confirms the "student

development-centered” evaluation orientation.

Table 2: A Summary of the Weight Data of Each Indicator in the Evaluation System of the All-round Education Mentor Group

First-level indicator	weight (%)	Second-level indicator	weight at the same level (%)	Global indicator weight (%)	Third-level indicator	weight at the same level (%)	Global indicator weight (%)
Input Evaluation	13.4	Tutor Team Development	32	4.29	Number of supervisors	44.4	1.9
					Mentor type	55.6	2.4
		External Cooperation Resources	12.3	1.7	Families and society work together to educate people	0.60	1.7
		Incentive Mechanism	55.7	7.5	Mentor motivation	0.63	7.5
Process Evaluation	41.7	Ideological and Political Education	8.5	3.5	Carry out various theme education activities	0.60	3.5
		Research and Academic Growth Guidance	26.7	11.1	Professional knowledge guidance	36.4	4.1
					Guidance on scientific research projects	63.6	7.1
		Innovation and Entrepreneurship Guidance	22.9	9.6	Guidance for subject competitions and practical activities	63.2	6
					Hold lectures, forums and simulation practices on innovation and entrepreneurship	37.8	3.5
Output Evaluation	44.9	Mental Health Education	16.4	6.9	Carry out mental health education activities	0.65	6.9
		Employment Guidance	25.4	10.6	Conduct vocational aptitude tests	26.7	2.8
		Students' Comprehensive Evaluation of the Tutor Team	13.7	6.2	Students' awareness of the mentor team	18	1.1
					Students' satisfaction with the mentor team	58.7	3.6
		Ideological and Political Development	6.9	3.1	Alumni's evaluation of the mentor team	23.3	1.4
					Moral education level	0.63	3.1
		Academic Level	16.3	7.3	Participated in the supervisor's scientific research projects	20.4	1.5
					Publication of papers and patents	41.9	3.1
					Student grades	37.7	2.8
		Competency Development	36.7	16.5	Participation in subject competitions and social practices	77	12.7
					Cultural and sports activities	23	3.8
		Employment Outcomes	26.3	11.8	Graduate employment rate	29.3	3.5
					The civil service examination rate of graduates	28.9	3.4
					The rate of graduates taking the postgraduate entrance examination	41.8	4.9

4. Discussion

In this study, the Analytic hierarchy process (AHP) was adopted to calculate the weights of the indicators, and the consistency test ($CR < 0.1$) was conducted to ensure the reliability of the results. Among the first-level indicators, the weight of output evaluation is the highest (44.9%), followed by process evaluation (41.7%), and the proportion of input evaluation is 13.4%,

highlighting the core position of educational effectiveness and implementation process. Among the secondary indicators, ability development (16.5%), employment situation (11.8%), and scientific research growth guidance (11.1%) have the highest weights. Among the third-level indicators, participation in subject competitions and social practice (12.7%), employment guidance services (7.8%), and mentor incentives (7.5%) have become key evaluation points, providing clear quantitative basis for actual evaluation.

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Digital Reconstruction of Empathy and Praxis: A Mixed-Methods Investigation into the Effectiveness of Online Social Work Experimental Teaching Strategies

Ruifang Zhao*

School of Public Administration, Shandong Technology and Business University Shandong Yantai, 264005, China

**Corresponding author: Ruifang Zhao*

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Abstract: The unanticipated onset of the COVID-19 pandemic has functioned as a profound exogenous shock to the global ecosystem of higher education, precipitating a radical migration from traditional pedagogical environments to digital modalities. While theoretical disciplines have adapted to this “Emergency Remote Teaching” with relative fluidity, practice-based professions such as social work face a unique ontological crisis. Grounded in the interpretivist paradigm and utilizing the specific reform context of the School of Shandong Technology and Business University, this study empirically investigates the efficacy and optimization strategies of online experimental teaching for the “Group Social Work” curriculum. Adopting a rigorous convergent parallel mixed-methods design, the research synthesizes quantitative data from 165 undergraduate respondents with thick qualitative descriptions derived from semi-structured interviews with 25 participants. The empirical results unveil a complex “Digital Paradox”: while purely online instruction successfully transmits declarative knowledge, it creates a significant “Empathy Gap” that hinders the cultivation of intersubjective professional skills. However, the data further suggests that a “Blended Experiential Learning” model, when supported by high “Teaching Presence” and “Social Presence,” can effectively mitigate these deficits. Drawing upon the Community of Inquiry (CoI) framework, this paper proposes a systemic optimization strategy—the “Three-Dimensional Reconstruction Model”—integrating pedagogical process re-engineering, technological affordance maximization, and developmental assessment reform. The findings offer a critical roadmap for the modernization of social work education in the post-pandemic era, arguing for a shift from “virtual replication” to “digital transformation.”

Keywords: Social Work Education; Experimental Teaching; Digital Empathy; Community of Inquiry; Mixed-Methods Research; Pedagogical Reform

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1.Introduction

1.1 The Digital Imperative and the Crisis of Corporeal Presence

The trajectory of higher education in the twenty-first century has been irrevocably altered by the intersection of the Fourth Industrial Revolution and the global public health crisis triggered by COVID-19. Since early 2020, the mandate from the Chinese Ministry of Education to “Suspend Classes Without Suspending Learning” has catalyzed the largest-scale experiment in online education in human history. This digital migration, while preserving the continuity of academic instruction,

has simultaneously exposed the fragility of practice-based pedagogies. Social work, as an applied social science rooted in humanism and social solidarity, relies fundamentally on the “use of self” as a therapeutic instrument. The Council on Social Work Education (CSWE) and the China Association for Social Work Education have consistently emphasized that professional competence is a holistic integration of values, knowledge, and skills that must be cultivated through direct, embodied interaction.

In the traditional “Group Social Work” laboratory, learning is situated in the physical proximity of bodies in space. Students learn to read micro-expressions, interpret the shifting energy of a room, and modulate their own non-verbal communication to build rapport. The migration of these intimate interactions to platforms such as Tencent Meeting (VooV Meeting) and Rain Classroom introduces a layer of technological mediation that strips away these essential sensory cues. This phenomenon, which we term “Corporeal Absence,” creates a profound pedagogical dilemma. When the client becomes a pixelated image and the group circle becomes a grid of black boxes, the ontological security of the therapeutic space is compromised. The central research problem of this study, therefore, is not merely technical but epistemological: Can the core competencies of social work—specifically empathy, group facilitation, and professional identity—be authentically constructed in a disembodied digital environment? If so, what are the specific mechanisms of transmission, and how can pedagogical strategies be optimized to bridge the digital divide?

1.2 Research Context: The Local Reform Initiative at SBTBU

This inquiry is not conducted in a vacuum but is deeply embedded in the specific institutional context of the School of Shandong Technology and Business University (SBTBU). As one of the pioneering institutions in Shandong Province to establish a social work program, the university has developed a distinctive “Dual-Track” training model that integrates classroom experimentation with community service. Under the leadership of the project host, Zhao Ruifang, and team members Lu Rumin, Zhao Shuliang, and Yang Xiaolong, the department has cultivated a rich ecosystem of practical training platforms. These include the on-campus “Angel Home” service center, which focuses on the resilience of migrant children, and the “Beidou Star” Social Work Service Center, which serves the elderly population.

Prior to the pandemic, these platforms provided a seamless transition from the “Social Work Laboratory” to the real world. However, the recurring waves of the pandemic and the subsequent campus lockdowns severed these physical connections. The teaching team observed a divergence in student performance during the shift to online experimental teaching. While some students demonstrated remarkable digital resilience, utilizing chat functions and virtual backgrounds to create new forms of engagement, others experienced profound alienation and “Zoom fatigue,” leading to a fragmentation of their professional identity. This study, funded as a university-level teaching reform project (Project No. F06), aims to systematically evaluate these observations. By moving beyond anecdotal evidence to rigorous empirical analysis, the project seeks to construct a localized, evidence-based model for online social work education that can serve as a reference for similar institutions across China.

1.3 Research Significance and Objectives

The significance of this study is threefold. Theoretically, it contributes to the nascent literature on “Digital Social Work” by testing the applicability of Western pedagogical frameworks, such as the Community of Inquiry (CoI), within the specific cultural and institutional context of Chinese higher education. Practically, it provides a set of actionable, data-driven optimization strategies for frontline educators who are struggling to maintain teaching quality in a hybrid learning environment. Policy-wise, it offers empirical evidence to support university administrators in allocating resources for the digital infrastructure required for high-quality experimental teaching. The primary objectives of this research are: (1) to quantitatively measure the impact of different teaching modalities (Pure Online vs. Hybrid vs. Traditional) on students’ skill acquisition and professional identity; (2) to qualitatively explore the lived experiences of students and instructors to understand the “black box” of digital interaction; and (3) to develop a comprehensive optimization strategy that harmonizes technological affordances with humanistic professional values.

2. Literature Review and Theoretical Framework

2.1 The Paradigm Shift: From Apprenticeship to Digital Simulation

The historical evolution of social work pedagogy has been characterized by a continuous tension between the “apprenticeship model,” which emphasizes immersion in the field, and the “academic model,” which prioritizes theoretical rigor ^[1]. The introduction of “experimental teaching” or “laboratory education” in the late 20th century attempted to bridge this gap by creating controlled environments for skill acquisition. Scholars such as Bogo (2015) and Shulman (2005) have long argued that the “signature pedagogy” of social work involves the simulation of practice situations where students can experiment with professional roles without the risk of harming actual clients ^{[2][3]}.

However, the integration of digital technology into this signature pedagogy has been met with historical resistance. Prior to 2020, the dominant narrative in social work literature viewed online education with skepticism. Reamer (2013), a leading voice in social work ethics, cautioned that digital practice could compromise confidentiality and boundary management ^[4]. Critics argued that the “high-touch” nature of the profession was fundamentally incompatible with “high-tech” delivery methods. Nevertheless, the post-pandemic reality has forced a paradigm shift. Recent literature, such as the works of Mishna et al. (2012) and López-Peláez & Marcuello-Servós (2018), has begun to articulate the concept of “e-Social Work.” This emerging perspective posits that digital literacy is no longer an optional add-on but a core competency. The ability to build rapport via a screen, to assess a home environment through a webcam, and to manage group dynamics in a chat room are now essential skills for the modern practitioner. This study positions itself at the forefront of this shift, arguing that the goal of online experimental teaching is not merely to replicate the physical classroom, but to leverage the unique affordances of the digital medium—such as anonymity, asynchronous reflection, and recording capabilities—to enhance the learning process.

2.2 Theoretical Framework: The Community of Inquiry (CoI)

To analyze the complex dynamics of interaction in the online experimental course, this study adopts the Community of Inquiry (CoI) framework developed by Garrison, Anderson, and Archer ^[5]. The CoI framework posits that deep and meaningful learning in an online environment occurs at the intersection of three distinct but interdependent elements: Social Presence, Cognitive Presence, and Teaching Presence.

Social Presence refers to the ability of participants to identify with the community, communicate purposefully in a trusting environment, and develop interpersonal relationships by projecting their individual personalities into the digital space. In the context of the “Group Social Work” course, Social Presence is paramount. It is the digital equivalent of “group cohesion.” Without a strong sense of Social Presence, experimental groups devolve into collections of isolated individuals, making the simulation of group dynamics impossible.

Cognitive Presence is the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse. For experimental courses, this involves the higher-order thinking skills required to analyze a case, design an intervention, and reflect on the outcome. The challenge in online settings is to move beyond superficial information exchange to deep, critical inquiry.

Teaching Presence involves the design, facilitation, and direction of cognitive and social processes ^[6]. In an online setting, the instructor’s role shifts from a “sage on the stage” to a “facilitator in the cloud.” The instructor must not only deliver content but also actively manage the digital environment, troubleshooting technical issues and fostering a climate of psychological safety. This study hypothesizes that the quality of these three presences directly determines the effectiveness of the online experimental course.

2.3 Experiential Learning Theory in the Virtual Domain

Complementing the CoI framework is Kolb’s Experiential Learning Theory (ELT), which defines learning as “the process whereby knowledge is created through the transformation of experience.” ^[7] The cycle consists of Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. In a traditional laboratory setting, this cycle is seamless. However, in an online environment, the “Concrete Experience” is mediated by a screen. Critics argue that “Virtual Simulation” cannot replace the visceral reality of face-to-face interaction. However, proponents suggest that well-designed virtual scenarios can provide a safe, low-stakes environment for students to practice difficult skills. This paper posits that the optimization of online experimental teaching requires a deliberate pedagogical design that ensures all four stages of Kolb’s

cycle are activated, utilizing different digital tools for each stage—for example, using Tencent Meeting breakout rooms for experimentation and Rain Classroom discussion boards for asynchronous reflective observation^[8].

3. Methodology and Research Design

3.1 Research Design: A Convergent Parallel Mixed-Methods Approach

Given the complexity of measuring “teaching effectiveness” in a humanistic discipline, a single methodological approach would be insufficient. Therefore, this study employs a convergent parallel mixed-methods design. This approach allows for the concurrent collection and analysis of quantitative and qualitative data, which are then merged for interpretation. The quantitative strand utilizes a quasi-experimental survey design to test causal relationships between teaching modes and learning outcomes, providing breadth and generalizability. The qualitative strand uses a phenomenological approach to understand the lived experiences of the participants, providing depth and nuance. The rationale for this design is that while statistical data can reveal that a difference exists between online and offline learning, only qualitative narratives can explain why and how these differences manifest in the subjective experience of the students.

3.2 Participants and Sampling Strategy

The study was conducted at the School of Shandong Technology and Business University. The target population comprised undergraduate students majoring in Social Work from the cohorts of 2019, 2020, and 2021. These three cohorts represent a unique historical natural experiment: the 2019 cohort experienced the sudden, forced transition to online learning; the 2020 cohort experienced a planned, hybrid model; and the 2021 cohort entered a university environment where digital tools were already normalized. A stratified random sampling method was used to select participants for the quantitative survey. A total of 250 questionnaires were distributed via the “Wenjuanxing” platform, and 216 valid responses were retrieved, yielding an effective response rate of 86.4%. The sample consisted of 45 males (20.8%) and 171 females (79.2%), which accurately reflects the gender distribution of the social work discipline in China. For the qualitative component, a purposive sampling strategy was employed to select 20 students (representing high, medium, and low academic performance) and 5 key instructors (including the project team members) for in-depth semi-structured interviews.

3.3 Instrumentation

To ensure the validity and reliability of the data, the study utilized rigorously developed instruments.

1. The Online Social Work Learning Effectiveness Scale (OSWLES): This instrument was developed specifically for this study by the research team. It is grounded in the CoI framework and the educational standards of the China Association for Social Work Education. The scale comprises four sub-dimensions: Professional Knowledge Acquisition, Practical Skill Application, Professional Identity, and Course Satisfaction. Each item is measured on a 5-point Likert scale. Exploratory Factor Analysis (EFA) confirmed the four-factor structure, and the Cronbach’s alpha for the total scale was 0.892, indicating high internal consistency.

2. General Self-Efficacy Scale (GSES) - Social Work Adaptation: The standard GSES was adapted to the specific context of social work practice to measure students’ confidence in specific tasks, such as facilitating a group discussion online or managing a conflict between group members.

3. Interview Protocol: The interview guide was designed to elicit detailed narratives regarding the participants’ experiences. Key questions included: “How does role-playing on Tencent Meeting differ from the physical classroom in terms of your emotional engagement?” “Can you describe a specific moment where you felt disconnected from your group members?” and “How did the instructor support your learning during technical difficulties?”

4. Empirical Results and Analysis

4.1 Quantitative Findings: The Divergence of Knowledge and Skill

The statistical analysis of the survey data provides a nuanced picture of the impact of teaching modes on student learning outcomes. One-way Analysis of Variance (ANOVA) was conducted to compare the means of the three teaching modes: Pure Online (Emergency Remote Teaching), Hybrid Model (Blended Learning), and Traditional (Face-to-Face).

Table 1: Comparative Analysis of Learning Outcomes Across Teaching Modalities

Dependent Variable	Pure Online (n=72) Mean (SD)	Hybrid Model (n=74) Mean (SD)	Traditional (n=70) Mean (SD)	F-Value	p-Value	Effect Size (η^2)
Professional Knowledge	3.82 (0.65)	4.15 (0.58)	3.95 (0.62)	5.67	.004**	0.051
Practical Skill Application	3.45 (0.78)	3.92 (0.69)	4.05 (0.64)	12.34	.000***	0.104
Professional Identity	3.60 (0.72)	3.88 (0.65)	3.98 (0.61)	6.12	.002**	0.054
Course Satisfaction	3.55 (0.80)	4.02 (0.70)	3.90 (0.75)	8.45	.000***	0.073
Social Presence	3.12 (0.85)	3.75 (0.72)	4.10 (0.68)	28.56	.000***	0.211

Note: ** $p < .01$, *** $p < .001$. Scale range 1-5.

The data presented in Table 1 reveals a critical dichotomy. In terms of Professional Knowledge Acquisition, the Hybrid Model group scored significantly higher ($M=4.15$) than both the Pure Online and Traditional groups. This suggests that the online environment is highly effective for the transmission of explicit, declarative knowledge. The use of recorded lectures and digital reading materials allows students to digest theoretical concepts at their own pace, leading to deeper cognitive retention.

However, a different pattern emerges for Practical Skill Application. Here, the Pure Online group scored the lowest ($M=3.45$), significantly lagging behind the other two groups. This empirical evidence supports the hypothesis that the acquisition of tacit, embodied skills—such as counseling techniques, empathetic responding, and conflict mediation—is hindered in a purely digital environment. The lack of immediate, three-dimensional feedback makes it difficult for students to calibrate their interventions. Notably, the Hybrid Model group achieved scores ($M=3.92$) that were statistically comparable to the Traditional group ($M=4.05$), indicating that a well-designed mix of online theory and offline (or intensive online synchronous) practice can achieve near-parity with traditional methods.

The most striking disparity was found in Social Presence, where the Pure Online group scored drastically lower ($M=3.12$). This confirms the CoI theory that building a sense of community is the most significant challenge in remote education. Without the casual, informal interactions that occur before and after class—the “hallway conversations”—students in the online group felt isolated and disconnected from their peers, which in turn negatively impacted their Professional Identity formation. To further investigate the determinants of Professional Identity, a multiple regression analysis was conducted.

Table 2: Multiple Regression Analysis Predicting Professional Identity in Online Environments

Predictor	Unstandardized B	Std. Error	Standardized β	t	p	VIF
(Constant)	1.05	0.28		3.75	.000	
Social Presence	0.42	0.06	0.45	7.02	.000***	1.45
Teaching Presence	0.28	0.07	0.31	4.15	.000***	1.62
Cognitive Presence	0.15	0.06	0.18	2.45	.015*	1.55
Technical Ease	0.08	0.05	0.09	1.60	.112	1.10

$R^2 = 0.62$, Adjusted $R^2 = 0.61$. Dependent Variable: Professional Identity Score.

Table 2 demonstrates that Social Presence is the strongest predictor of Professional Identity ($\beta = 0.45$, $p < .001$), followed by Teaching Presence. This finding is pivotal for social work education. It implies that for students to internalize the identity of a social worker, they must first feel a sense of belonging to a professional community. The technical quality of the platform (Technical Ease) is not a significant predictor, suggesting that the barrier to learning is not the hardware or software itself, but the human connection mediated through it.

4.2 Qualitative Findings: The Digital Empathy Gap and the Screen as Shield

The quantitative results outline the “what,” but the qualitative data illuminates the “why.” The thematic analysis of the interview transcripts revealed three dominant themes that characterize the student experience of online experimental learning.

Theme 1: The Digital Empathy Gap and Sensory Deprivation.

Participants frequently described a phenomenon of “emotional flatness” or sensory deprivation. In a physical classroom, empathy is transmitted through a complex interplay of mirror neurons, shared atmosphere, and non-verbal cues. Online, this signal is compressed. A student from the 2019 cohort, participating in a role-play on Tencent Meeting, articulated this vividly: “When I am leading a group online, I am looking at a grid of faces, but I can’t feel their energy. If a group member creates a silence, I don’t know if they are thinking deeply, holding back tears, or just checking their phone. That 3-second audio lag destroys the moment of empathy. I feel like a technician operating a machine, not a social worker helping a person.” This narrative underscores that the “Corporeal Absence” hinders the development of “use of self,” a core social work skill.

Theme 2: The Screen as a Shield – Psychological Safety for Introverts.

Contrary to the deficit narrative, a counter-intuitive theme emerged regarding psychological safety. Several students who identified as introverted or socially anxious reported that the online environment actually facilitated their participation. The physical separation provided by the screen acted as a protective shield, lowering the stakes of performance. One student noted: “In the real classroom, with everyone staring at me, I freeze. But online, I can turn off ‘self-view,’ and I have my notes right on the screen. I feel safer. I can focus on what I want to say without worrying about my body language.” This suggests that online experimental teaching may offer unique inclusive benefits for specific learner personalities, provided the interaction is carefully scaffolded.

Theme 3: Fragmentation of Group Dynamics.

Instructors, including team members Lu Rumin and Zhao Shuliang, observed that online groups struggled to move through the classic stages of group development (Tuckman’s Forming, Storming, Norming, Performing). Specifically, the “Storming” phase was often bypassed or suppressed. In a physical setting, conflict must be negotiated because participants are trapped in the same room. Online, it is too easy to “mute” oneself or physically walk away from the computer when tension arises. Consequently, many online groups remained in a state of “polite superficiality,” failing to reach the depth of interaction required for true therapeutic work. The digital medium, by reducing friction, paradoxically reduced the learning opportunities that come from managing friction.

5. Discussion and Optimization Strategies

5.1 Reinterpreting the Hybrid Advantage: From Binary Opposition to Ecological Integration

The empirical superiority of the Hybrid Model identified in the preceding results chapter compels a fundamental re-evaluation of the prevailing dichotomy between “online” and “offline” education. In the early stages of the pandemic, the academic discourse was often framed as a zero-sum competition, questioning whether digital surrogates could ever replace physical proximity. However, the data from the School of Shandong Technology and Business University suggests that this binary opposition is epistemologically flawed. The future of social work education does not lie in a forced choice between the brick-and-mortar classroom and the virtual meeting room, but rather in the strategic, ecological integration of both modalities to create a continuum of learning experiences.

The theoretical underpinning of this integration can be best understood through the lens of the “Flipped Classroom” pedagogical architecture, which effectively bifurcates the learning process based on cognitive load theory. In our optimized model, the acquisition of declarative knowledge—such as the theoretical history of social work, the specific clauses of the “Charity Law,” or the abstract principles of human behavior—is migrated to the asynchronous digital space. Utilizing platforms like Rain Classroom (Yu Ketang), students engage with these low-cognitive-load materials at their own pace, allowing for pause, rewind, and reflection, which is particularly beneficial for students who may struggle with the rapid pace of a live lecture. This asynchronous pre-loading effectively “primes” the cognitive apparatus of the student. Consequently, the valuable and finite resource of synchronous time—whether it occurs in a physical laboratory or a high-intensity online workshop—is liberated from the burden of passive information transmission.

This structural shift allows the synchronous session to be exclusively dedicated to high-order cognitive tasks as defined by Bloom’s Taxonomy: application, analysis, evaluation, and creation. For a course like “Group Social Work,” this means that when students convene on Tencent Meeting or in the physical classroom, they are not coming to “learn” what a group

norm is, but to “negotiate” a group norm in real-time. The instructor’s role transitions from a broadcaster of content to a facilitator of complex interpersonal dynamics. The hybrid advantage, therefore, is not merely about convenience; it is about the optimization of pedagogical intensity. By offloading the “dry” content to the digital realm, we create space for the “wet,” messy, and emotional work of empathy construction to take center stage during synchronous interactions. This synthesis addresses the “Digital Empathy Gap” not by ignoring technology, but by using technology to handle the informational burden, thereby allowing human interaction to focus purely on emotional and relational processing.

5.2 The “Three-Dimensional Optimization Strategy” (TDOS)

Building upon the empirical findings which highlighted specific deficits in Social Presence and Practical Skill Application in purely online settings, and integrating the successful elements of the hybrid pilot, this paper proposes a comprehensive “Three-Dimensional Optimization Strategy” (TDOS). This strategy is designed to reconstruct the social work experimental teaching system at Shandong Technology and Business University, ensuring it is resilient to future public health crises while advancing the modernization of the discipline.

Dimension One: Pedagogical Process Reconstruction – The “Micro-Practice” and “Digital Fishbowl” Model

The first dimension of optimization targets the structural design of the experimental session itself to combat the pervasive phenomena of “Zoom fatigue” and the “Digital Empathy Gap.” Traditional experimental classes often involve long, uninterrupted role-plays (e.g., 45 to 60 minutes) designed to simulate a complete counseling session. Our research indicates that in an online environment, maintaining the cognitive and emotional vigilance required for such duration is neurologically exhausting, leading to a rapid degradation of empathy after the 20-minute mark. Therefore, we propose a radical re-engineering of the temporal structure of the class into granular “Micro-Practice” modules.

Under this model, complex experimental tasks are deconstructed into discrete, manageable skills—such as “empathetic reflection,” “confrontation,” “summarization,” or “managing silence.” Students engage in these specific skills in intense, 10-to-15-minute bursts. For instance, in a module focusing on “empathetic validation,” a student might be presented with a standardized client statement rooted in the “Angel Home” project context (e.g., a migrant child saying, “I don’t want to go to school because they laugh at my accent”). The student is tasked not with solving the whole problem, but solely with demonstrating three different variations of empathetic validation. This granularity allows for focused cognitive processing without the overwhelming pressure of managing a full clinical arc.

Furthermore, to address the passivity of observers in online breakout rooms, we advocate for the implementation of the “Digital Fishbowl” technique utilizing the “Spotlight” feature in Tencent Meeting. In this configuration, a small group of active participants (the fish) is visually spotlighted on the screen, while the rest of the class (the bowl) turns off their cameras and microphones. However, unlike a physical fishbowl where the audience is silent, the digital audience is tasked with providing real-time, timestamped feedback in the chat box or via “Danmu” (bullet screen comments). They are instructed to type specific codes (e.g., “#EMP” for good empathy, “#MIS” for a missed cue) the moment they observe a behavior. This transforms the passive observer into an active, data-generating analyst. When the role-play concludes, the instructor does not need to rely on vague memories of what happened; they can scroll through the chat log to provide precise, frame-by-frame feedback, such as, “At 10:15 AM, thirty of your classmates noted that you interrupted the client. Let’s re-watch that specific moment.”

Dimension Two: Technological Empowerment – Enhancing Presence and Ideological Integration

The second dimension focuses on the instrumental level, leveraging advanced technologies to enhance Social Presence and integrate “Curriculum Ideology and Politics” (Kecheng Sizheng). Our regression analysis identified Social Presence as the primary predictor of Professional Identity. Therefore, technology must be employed not merely to transmit audio and video, but to humanize the experience and bridge the psychological distance. Instructors must evolve into “Techno-Pedagogical Architects.” This role involves mastering “online immediacy” behaviors. For example, during the “Beidou Star” elderly service simulation, instructors should utilize the “Breakout Room Broadcast” function not just for timekeeping, but to send encouraging prompts or “inject” new plot twists into the simulation (e.g., “News flash: The elderly client’s son just called and said he isn’t coming for Spring Festival”), thereby keeping the energy dynamic and unpredictable.

Moreover, to overcome the sensory deprivation inherent in 2D video conferencing, the curriculum should aggressively integrate Virtual Reality (VR) simulations for high-risk and emotionally complex scenarios. Current 2D role-plays are often insufficient for teaching crisis intervention, such as suicide prevention or domestic violence de-escalation, because the student does not feel the visceral “fight or flight” response safely behind a screen. A VR module, potentially developed in collaboration with the university’s computer science department, places the student in a 360-degree immersive environment where they must confront a frantic client. The VR headset tracks the student’s gaze and hesitation, providing biometric feedback on their stress response. This immersion allows students to practice emotional regulation in a safe, controlled environment before stepping into real-world practice.

Crucially, this technological dimension also serves as a vehicle for ideological education. By utilizing digital storytelling tools, students can curate multimedia narratives of China’s grassroots social workers fighting the pandemic. Integrating these narratives into the experimental course—for example, analyzing the crisis management strategies of community workers in Wuhan or Shanghai—anchors the technical skills of social work in the broader context of national service and social responsibility. This ensures that the “Technological Empowerment” does not lead to technocratic alienation, but rather reinforces the humanistic and patriotic values of the profession.

Dimension Three: Evaluation Reform – Process Over Outcome and Reflexivity

The third and final dimension necessitates a paradigm shift in assessment logic, moving from “Outcome-Based” to “Process-Oriented” evaluation. Traditional assessment in social work experimental courses often relies heavily on a final, summative role-play performance at the end of the semester. In an online setting, this high-stakes approach is deeply flawed; it is vulnerable to random technical glitches (e.g., a momentary lag causing a student to interrupt a client) and exacerbates performance anxiety, which can mask true competence.

We advocate for the implementation of a “longitudinal Electronic Portfolio” (e-Portfolio) system. Throughout the semester, students are required to submit raw screen recordings of their micro-practice sessions. Accompanying these recordings, they must submit a “Reflective Audio Log” or a written analysis where they critique their own performance. For instance, a student might write, “In the video at 05:20, I noticed my tone was too aggressive. I was feeling anxious because the client was silent. If I could do it again, I would sit with the silence.” This method capitalizes on the “recordability” of online teaching. The digital record becomes a mirror for the self. The assessment grade, therefore, is weighted heavily on the quality of the reflection and the trajectory of improvement rather than the perfection of the performance itself. This aligns with the cultivation of “Cognitive Presence” in the CoI framework, fostering the habit of reflexive practice which is the hallmark of a mature social worker.

6. Conclusion

The digital transformation of higher education is not a temporary aberration but a permanent structural evolution. For social work education, this transition presents an existential challenge: how to preserve the human soul of the profession in a mechanized medium. This study, grounded in the practice of Shandong Technology and Business University, confirms that while purely online formats struggle to replicate the nuanced intimacy of social work practice, a scientifically designed Hybrid Model can effectively cultivate professional competence.

The findings reveal that the “Digital Empathy Gap” is real, but it is not insurmountable. By deliberately engineering Social Presence, leveraging the unique affordances of digital tools for reflective practice, and adopting a process-oriented assessment system, educators can bridge the distance imposed by screens. The “Three-Dimensional Optimization Strategy” proposed herein offers a viable path forward. It suggests that the role of the social work educator is evolving from a content expert to a facilitator of digital communities and a designer of learning experiences. As we move forward, the goal is not to return nostalgically to the pre-pandemic past, but to forge a new future where technology serves humanity, making social work education more resilient, accessible, and responsive to the needs of a digital society. The essence of social work—connection, empathy, and service—remains constant; it is only the medium of its transmission that is being reimagined.

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The authors declare that there is no conflict of interest regarding the publication of this paper.

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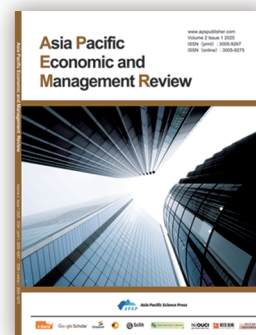
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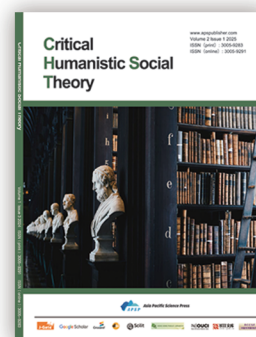
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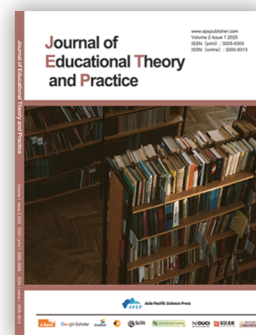
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