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Cultivating Professionalism in Medical Laboratory Students through Ideological and Political Education in the Context of Integrating Medical Ethics and Practice

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Abstract: Medical laboratory science is an essential component of healthcare services. The quality of laboratory services is not only highly correlated with doctors' theoretical knowledge and practical skills but is also greatly influenced by their professional ethics and ideological standards. Therefore, it is necessary to implement ideological and political education in the curriculum for medical laboratory students, aiming to elevate their ideological and moral standards, enhance their work enthusiasm, and alleviate job burnout. This article explores the positive impact of ideological and political education on cultivating professionalism in medical laboratory students and discusses its application in this context, considering the current situation of professional ethics training for these students.

Keywords: Integration of medical ethics and practice; Ideological and political education in curriculum; Medical laboratory students; Professionalism; Teaching strategies

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1. Introduction

Professionalism is a crucial indicator for evaluating the personal qualities of medical students, which should be emphasized alongside theoretical knowledge and practical skills. As clinical laboratory diagnosis plays a pivotal role in healthcare services, it is imperative to incorporate ideological and political education into the traditional teaching mode for interns. This dual approach aims to enhance both professional skills and humanistic qualities, shifting the limited perception of traditional laboratory practitioners being responsible only for samples towards a people-oriented philosophy. This shift provides interns with the inherent motivation for future career development and is an essential pathway to comprehensively improve the quality of intern teaching, deserving high attention from relevant educators ^[1].

2. Positive impact of ideological and political education on cultivating professionalism in medical laboratory students

The concept of “a doctor with a benevolent heart” has always been a requirement for medical service providers and an important criterion for evaluating their suitability for the job. However, in the traditional training of undergraduate interns, some teaching methods often overlook the cultivation of humanistic qualities through ideological and political education. Entering a new era, the fine traditions of the Party need to be implemented in various industries, from not taking a single needle or thread from the masses to the spirit of Lei Feng, and further to the perseverance embodied in the aerospace field, all reflecting the importance of ideological and political education. For medical laboratory students, they not only need to possess high professional qualities, such as adequate theoretical knowledge reserves and strengthened practical skills training, but also require lofty morals and ideals. By understanding and prioritizing patients’ needs, they can improve the quality of medical services and optimize doctor-patient relationships. This reflects the high demand for the quality of medical laboratory students in the context of integrating medical ethics and practice. Following the fine tradition of careful planning and consideration for others, medical laboratory interns should also closely follow the Party’s call and strengthen their ideological and political education ^[2].

The positive impact of ideological and political education in courses on cultivating the professional ethics of medical laboratory students is primarily reflected in shaping their correct concepts and forming a proper outlook on life and values. Medical laboratory students may face many ethical issues in the future. Compared to clinical and nursing professions, although medical laboratory students have fewer opportunities to directly interact with patients, they may still be deeply involved in ethical issues, and the ethical and moral principles required of them are no different. Focusing on the current situation, hospital inspection items often appear in sets, and single-item inspections are very rare. Although packaged inspections can increase the probability of disease diagnosis and provide doctors with more accurate diagnostic references, for patients, it may be accompanied by an increase in burden and make it difficult for patients to truly trust the necessity of the inspection items. In addition, inspection personnel in some hospitals may make mistakes due to work errors, such as failing to carefully check patient information or taking the wrong inspection report, leading to incorrect inspection results, increasing patient troubles, and causing more doctor-patient disputes. This is also the necessity of ideological and political education in courses. The development of related courses is closely related to the professional ethics of medical laboratory students. Based on the perspective of integrating medicine and ethics, medical laboratory students also need to have a people-oriented philosophy, possessing noble medical ethics while improving their professional knowledge ^[3].

3. Current situation of professional ethics cultivation for medical laboratory students

Focusing on the practical level, currently, various sectors of society generally pay more attention to the moral cultivation of medical laboratory students, but the effect of related training is only satisfactory, and there is still much room for improvement. The reasons are diverse, including both objective and subjective factors. Objectively, some medical laboratory majors focus on improving professional skills as the main training direction in student cultivation, emphasizing skill improvement and not giving due attention to students’ professional ethics in assessments ^[4]. Over time, professional ethics will continue to be marginalized. Although some majors have implemented corresponding ideological and political courses and attach importance to cultivating students’ professional ethics, the teaching methods are relatively traditional and not deeply integrated

with current events, resulting in students only scratching the surface and not deepening their understanding of professional ethics, with obvious formalization. Subjectively, due to the fierce market competition faced by hospitals and the increasing work pressure on medical laboratory students, they also face a higher risk of moral dilemmas. Some medical laboratory students do not attach great importance to the significance of ideological and political education for future career development, failing to equate it with business skills, and have little interest in learning, making it difficult to implement the professional ethics requirements for medical students from the perspective of integrating medicine and ethics ^[5].

4. Ideas for applying ideological and political education in courses to cultivate professional literacy of medical laboratory students

4.1. Clarifying the teaching objectives of ideological and political education in courses

Medical laboratory teachers and students should pay high attention to ideological and political education in courses from a fundamental perspective. Besides learning basic knowledge, they should form a clear understanding of the importance of ideological and political education in courses and establish lofty ideals. Relevant colleges and majors should clarify the objectives of ideological and political education, enabling students to form correct viewpoints and establish firm beliefs. Furthermore, it is necessary to strengthen students' belief education, making them aware of the positive impact of ideological level on the improvement of professional level, enhancing their sense of responsibility for their positions, and encouraging them to bravely assume their position responsibilities. On this basis, attention should also be paid to cultivating a scientific spirit, enabling students to have a rigorous work style in practice and reducing the risk of making errors in future work ^[6].

4.2. Optimizing the content of ideological and political education in courses

Reasonable content for ideological and political education in courses can greatly enhance teaching quality. For example, the ideological and political elements of the current course content can be fully explored. When explaining relevant cases and response methods, students can be informed about the development history of relevant inspection technologies. Many researchers have willingly served as stepping stones, contributing to the development of the inspection industry and diligently studying, which is worthy of continuous learning reinforcement for medical laboratory students. This can make students aware of the difficulties in the development of medical laboratory science and help them establish correct work concepts. Medical laboratory majors can also introduce ethics education, enabling medical laboratory students to find a balance between medical technology and patient services in their future work, and truly value and dare to take on their position responsibilities ^[7].

In addition, a large number of cases should be introduced into the teaching content, allowing medical laboratory students to recognize that inspection work can also shine. Taking hematology inspection projects as an example, teachers can play videos of medical laboratory students donating hematopoietic stem cells to leukemia patients, deepening students' understanding of socialist core values. They can also show work cases of medical students who perform bone marrow cell smear inspections, repeating boring work day after day, to cultivate students' professional ethics of being obscure and dedicated. Furthermore, teachers can introduce the case of Tu Youyou extracting artemisinin, playing documentaries about Tu Youyou's experimental team, allowing students to experience the blow of repeated operation failures and feel the spiritual strength of facing difficulties and working hard. This not only enables students to deepen their familiarity and understanding of inspection work but also shapes their correct professional ethics, making them unafraid of difficulties in their future work ^[8].

4.3. Innovating teaching methods for ideological and political education in courses

Much of the content in ideological and political education can be relatively dull. If it only involves the imparting of theoretical knowledge, it is likely to reduce students' interest in the lectures, negatively affecting teaching quality. Therefore, teachers need to devote themselves to innovating teaching methods, with students as the main focus, mobilizing their thinking abilities, stimulating their interest in the lectures, and enhancing their sense of participation in the classroom. Teachers can create videos (several minutes long) that reflect ideological and political education in the curriculum through micro-courses, flipped classrooms, and other formats, allowing students to watch freely and express their feelings. For a few ideas, teachers can provide appropriate guidance without blindly criticizing, to avoid damaging students' self-confidence^[9]. Teachers can also use group work to enable students to collaborate with each other and complete projects together through activities such as themed presentations. This not only helps students to increase their emphasis on ideological and political education in the curriculum but also strengthens teamwork among students. Furthermore, because ideological and political education is closely related to students' future work practices, teachers can adopt role-playing methods, setting up different performance scenarios such as nucleic acid testing during the epidemic, hospital blood routine testing, and parent-child relationship testing. Through role-playing, students can deepen their understanding of the importance of testing work, experience the significance of job responsibilities, and enhance their recognition of their own work value. Teachers can also use the classroom to hold challenge competitions, allowing students to face multiple challenging tasks simultaneously, simulating the high-pressure environment they may encounter in future work, honing their professional skills, and strengthening their sense of identification with professional ethics. Through innovative teaching methods, students' interest in learning will be further mobilized, and they will be able to recognize the importance of professional ethics in fulfilling testing job responsibilities, which is conducive to forming a positive learning cycle for related content^[10].

4.4. Integrating ideological and political education into practice

Laboratory medicine courses require a significant amount of practical experience, which can also serve as an opportunity for ideological and political education. Teachers need to deepen their communication with students to understand their difficulties and needs. When students feel bored with repetitive testing operations, teachers can patiently persuade them to recognize that only through repetition can they reduce errors and ensure accuracy. When students are intimidated by complex testing procedures, teachers need to provide appropriate encouragement, motivate students, and inform them that testing equipment and techniques are constantly updating and improving, thereby fostering a learning consciousness and recognizing the necessity of practical learning^[11]. If students are careless and make frequent errors, teachers must sternly remind them that every test can directly impact patients' diagnosis results, causing unpredictable economic and emotional stress. As laboratory medicine students, they must not only possess excellent professional skills but also maintain a sense of awe for their work, enhancing their rigor and dedication to ensure accurate diagnostic results. In summary, various difficulties encountered by students during practice can serve as ready-made materials for ideological and political education. Teachers need to strengthen communication with students and enhance their understanding to truly fulfill the goals of ideological and political education^[12].

5. Conclusion

In summary, ideological and political education is crucial for shaping the future professional ethics of laboratory medicine students. Relevant institutions and departments should emphasize the positive impact of ideological

and political education and address its current inadequacies. This can be achieved by clarifying educational objectives, optimizing educational content, innovating teaching methods, and integrating ideological and political education into practical experiences. These efforts will cultivate laboratory medicine professionals who value both professional skills and ethical standards.

Disclosure statement

The author declares no conflict of interest.

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A Study of China's Image in Vietnam's Nhan Dan (People's Daily): A Case Study of China-Related Coverage

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Abstract: This article takes all the China-related reports in Vietnam's Nhan Dan from 2016 to 2020 as the research object, and discusses the national image of China constructed by Vietnam's mainstream media from the aspects of the number of reports and the content of reports around the news theme. The study found that Nhan Dan gave China all-round attention, and reported extensively on key issues and social life related to China's politics, economy, and military affairs. The positive and negative images of China's national image presented in the reports coexist. The reports reflect the attitude of Nhan Dan as a mainstream media in Vietnam. The reports not only emphasize China's important position in international affairs, but also hold an attitude of risk awareness and threat vigilance.

Keywords: Vietnam; Nhan Dan newspaper; China's image; China-related reports

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1. Introduction

Vietnam and China, sharing contiguous territories and a long history of interactions, have maintained complex bilateral relations characterized by dramatic transformations. Their historical trajectory evolved from ancient times marked by alternating reverence and resistance toward the "Celestial Empire to the north," through the modern era of "comrades and brothers" revolutionary camaraderie, to abrupt transitions as "most immediate adversaries," before realigning as "exemplars of socialist reform and opening-up." This relationship has witnessed profound oscillations and intricate detours. Currently, the two nations are advancing their Comprehensive Strategic Cooperative Partnership, actively exploring synergies between China's Belt and Road Initiative and Vietnam's Two Corridors and One Circle development framework, ushering in new collaborative opportunities. However, challenges persist due to sensitive issues like the South China Sea disputes, with political mutual trust remaining a critical impediment to deeper cooperation.

As a major Asian power, China's national image constitutes a pivotal element in Asian international

relations. Foreign media narratives directly shape domestic Vietnamese perceptions and attitudes toward China. Therefore, analyzing China's national image construction in Vietnamese mainstream media holds significant practical value for enhancing political trust, cultivating a favorable international discourse environment, and propelling collaborative development between the two nations.

2. Data source and research methodology

2.1. Data source

Established on March 11, 1951, Nhan Dan (The People) newspaper, the official organ of the Communist Party of Vietnam, serves as a paradigmatic representation of mainstream Vietnamese media with significant representativeness, authority, and influence. Selecting it as a research object allows for an accurate understanding of the construction of China's national image through its editorial stance and value orientation. Due to difficulties in obtaining print editions, this study focuses on the website (<https://cn.nhandan.vn/>) reports related to China from January 2016 to December 2020, conducting both quantitative and qualitative analyses to examine the patterns and trends in how China's national image is constructed in Vietnamese media discourse.

2.2. Research methodology

First, utilizing web-based literature collection tools with configured parameters, all China-related reports published on the Nhan Dan (People's Daily) website between January 2016 and December 2020 were downloaded. Subsequently, the collected articles were categorized based on quantitative metrics (e.g., publication frequency) and qualitative dimensions (e.g., thematic content, tone, and key topics). Corresponding classification tables adhering to academic tabulation standards were constructed, including components such as table numbering, concise titles, aligned numerical data, and explanatory footnotes. Finally, systematic data analysis was performed using methodologies such as descriptive statistics, content analysis, and temporal trend evaluation, culminating in empirically supported conclusions.

3. Statistics and analysis

A total of 1,268 China-related articles were retrieved from the Nhan Dan (People's Daily) website between 2016 and 2020. After removing 32 duplicate entries, the final sample comprised 1,236 articles. These articles were categorized into five thematic groups based on content analysis: (1) Politics/Diplomacy, (2) Economy, (3) Science, Education, Culture, Sports, and Public Health, (4) National Defense/Military Affairs, and (5) Other. Due to the sensitivity and geopolitical significance of South China Sea issues, articles addressing this topic were extracted from the broader "Politics/Diplomacy" category for independent statistical analysis. Quantitative analysis of annual and thematic distributions (see **Table 1** and **Figure 1**) revealed that the sampled articles reflect Nhan Dan's institutional role as Vietnam's state-run newspaper in propagating the Party's theoretical frameworks, policy directives, and strategic decisions, while disseminating critical information across domestic and international domains. The thematic emphasis further highlighted the Vietnamese mainstream media's focused attention on China's engagements in international affairs and its political-economic developments.

Table 1. Distribution of China-related articles by thematic category in Nhan Dan (People’s Daily) website, 2016–2020

Year	Politics /diplomacy	South China Sea issues	Economy	Science, education, culture, sports & public health	National defense /military affairs	Other	Annual total/ percentage
2016	90	55	27	13	30	4	219/17.72%
2017	120	24	48	15	25	0	232/18.77%
2018	90	13	96	26	18	6	249/20.14%
2019	84	7	149	17	18	0	275/22.25%
2020	35	1	202	12	11	0	261/21.12%
Total /percentage	419 /33.91%	100 /8.09%	522 /42.23%	83 /6.72%	102 /8.25%	10 /0.80%	1,236/100%

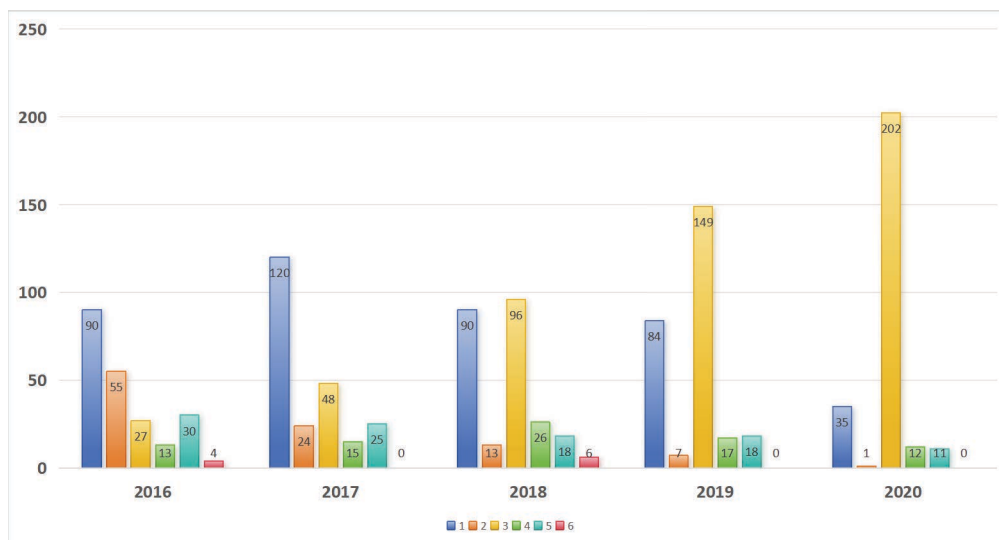


Figure 1. Distribution of China-related articles by thematic category in Nhan Dan (People’s Daily) website, 2016–2020 (Explanation: Politics/Diplomacy_1; South China Sea Issues_2; Economy_3; Science, Education, Culture, Sports & Public Health_4; National Defense/Military Affairs_5; Other_6)

3.1. Political/diplomatic news reporting

In the coverage related to China on the Nhan Dan (People’s Daily) website from 2016 to 2020, political/diplomatic news constituted 419 articles, accounting for 33.91% of the total China-related reporting over the five-year period. This category ranked second in terms of total coverage volume. Based on content, these reports can be classified into four subcategories: “Exchanges between National Leaders,” “Interactions among Central Ministries and Commissions,” “Engagements between Provincial/Municipal Governments,” and “Non-Governmental Exchanges.” The article counts and percentage distributions of these subcategories within the political/diplomatic news category are detailed in **Table 2**.

For annual article counts, from 2016 to 2020, annual reporting volumes exceeded 80 articles, while the 2020 count dropped to 35 articles, attributable to reduced bilateral engagements due to the COVID-19 pandemic. In terms of thematic distribution, from 2016 to 2020, official-level interactions between China and Vietnam significantly outpaced non-governmental exchanges, with 91.88% of articles focusing on official engagements. Among official interactions, those involving central ministries and commissions dominated

political/diplomatic coverage, accounting for 52.5% of such reports.

Regarding content focus, bilateral relations between China and Vietnam emerged as a central theme, with cooperation and development constituting primary reporting priorities. Frequent high-level leadership exchanges guided bilateral relations, driving close consultations at the apex.

Notably, the 220 articles on Interactions among Central Ministries and Commissions highlighted concerted efforts to implement consensus from leadership meetings and advance cross-sectoral collaboration; the 91 articles on Engagements between Provincial/Municipal Governments documented project-specific negotiations between Vietnamese localities and Chinese counterparts, including Beijing, Shanghai, Guangdong, Zhejiang, Hunan, Jiangsu, Guangxi, Guizhou, Yunnan, Jiangxi, Sichuan, Chongqing, Hebei, Tibet, and Hong Kong; the 34 articles on Non-Governmental Exchanges reflected robust growth in grassroots interactions.

Overall observations show that the reporting consistently emphasized consolidating traditional Sino-Vietnamese friendship, enhancing political mutual trust, and aligning development strategies. Core narratives prioritized synergy between the Belt and Road Initiative and Vietnam’s “Two Corridors and One Economic Circle” framework to upgrade practical cooperation, fostering a mutually beneficial comprehensive partnership. The high reporting density underscores Vietnamese mainstream media’s acute focus on political-diplomatic dynamics, mirroring the positive trajectory of bilateral relations and tangible progress in the China-Vietnam Comprehensive Strategic Cooperative Partnership.

Table 2. Distribution of political/diplomatic news articles in China-related reporting on Vietnam’s Nhan Dan website (2016–2020)

Year	Exchanges between National Leaders	Interactions among Central Ministries and Commissions	Engagements between Provincial/Municipal Governments	Non-Governmental Exchanges	Annual total/ percentage
2016	14	46	24	6	90/21.48%
2017	26	64	21	9	120/28.64%
2018	10	53	18	9	90/21.48%
2019	17	43	16	8	84/20.05%
2020	7	14	12	2	35/8.35%
Total/percentage	74/17.66%	220/52.5%	91/21.72%	34/8.12%	419/100%

3.2. South China Sea issues in news reports

From 2016 to 2020, the Vietnamese People’s Daily website published 100 articles related to the South China Sea (referred to by Vietnam as the “East Sea”), accounting for 8.09% of its total China-related coverage during this five-year period. This category ranked fourth in overall news volume. These articles can be classified into five thematic categories based on content: (1) Propaganda to Vietnamese citizens regarding sovereignty claims over the South China Sea (termed the “East Sea” by Vietnam). (2) Vietnam’s opposition to China’s actions in the South China Sea. (3) International conference discussions on South China Sea issues. (4) Perspectives from other organizations on South China Sea disputes. (5) Sino-Vietnamese maritime cooperation consultations for joint development. The distribution of article counts and percentage representation within this category is detailed in **Table 3**.

From the Annual Report Count Perspective, the year 2016 witnessed the highest number of reports,

totaling 55 articles, accounting for 55% of the total coverage of this category. However, from 2016 to 2020, the volume of reports exhibited a year-on-year exponential decline. This trend reflects the shifting media focus driven by geopolitical hotspots. The Sino-Vietnamese “Haiyang Shiyou 981” oil rig standoff in May 2014 and the Philippines v. China South China Sea Arbitration Case (2013–2016) elevated the South China Sea issue to a high-priority political concern among China, Vietnam, the Philippines, and other regional stakeholders. Nhan Dan (People’s Daily) demonstrated intense scrutiny of the South China Sea issue through its frequent reporting in 2016, which also underscored Vietnam’s political stance and attitude. Between 2017 and 2018, Chinese and Vietnamese national leaders conducted three reciprocal visits, further shaping bilateral dynamics.

In 2019, Vietnamese national leaders visited China twice. In 2020, Chinese and Vietnamese leaders engaged in three telephonic exchanges. Over these four years, frequent high-level reciprocal visits emphasized enhancing political mutual trust, managing disputes, and deepening mutually beneficial cooperation across diverse fields. Bilateral cooperation and development became the focal point of Nhan Dan (People’s Daily) coverage, while attention to the South China Sea issue relatively diminished—a shift clearly reflected in the year-on-year decline in related news reports during this period.

From thematic coverage analysis, 95% of news reports focused on Vietnam’s propaganda regarding territorial sovereignty disputes in the South China Sea. 39%: Public education campaigns targeting Vietnamese citizens on Vietnam’s sovereignty claims over the South China Sea. 33%: Coverage of international conferences and perspectives from organizations discussing the South China Sea issue. 20%: Reports opposing China’s actions in the South China Sea. 5% of news reports detailed specific progress in China-Vietnam maritime cooperation and joint development consultations.

From content analysis: The South China Sea issue has transitioned from confrontation to cooperation, with media narratives shifting from large-scale sovereignty-related propaganda to constructive interactions based on bilateral negotiations.

Key strategies include:

Domestically, Vietnam organized exhibitions such as “Paracel and Spratly Islands Belong to Vietnam: Historical and Legal Evidence” to strengthen public education on national territorial sovereignty awareness.

Internationally, Vietnam’s Ministry of Foreign Affairs publicly opposed China’s maritime actions, endorsed the 2016 South China Sea arbitration ruling, amplified negative portrayals of China, and highlighted international support for the arbitration tribunal’s decision to cultivate global solidarity and shape international opinion.

In “China-Vietnam Maritime Cooperation and Joint Development Consultations”:

Reports primarily covered working-group negotiations, emphasizing commitments to implement consensus reached by leaders, avoid actions complicating the situation, and safeguard regional peace and stability.

Analytical conclusions: Despite historical tensions over the South China Sea, both sides are actively addressing maritime disputes through dialogue and consultations, demonstrating a positive trajectory in regional dynamics. The South China Sea remains a sensitive issue impacting bilateral relations and political trust. Upholding the principle of “good-neighborliness and comprehensive strategic partnership,” continued advocacy for “shelving disputes and pursuing joint development” aligns with the shared interests of China, Vietnam, and regional stakeholders. Resolving disputes amicably and maintaining peace in the South China Sea will foster a favorable environment for advancing bilateral cooperation and meeting regional expectations.

Table 3. Thematic distribution of South China Sea-related coverage in China-focused reports on Vietnam's People's Daily website (2016–2020)

Year	Propaganda to Vietnamese citizens on sovereignty claims over the South China Sea	Vietnam's opposition to China's actions in the South China Sea	International conference discussions on South China Sea issues	Perspectives from other organizations on South China Sea disputes	Sino-Vietnamese maritime cooperation consultations for joint development	Annual total/percentage
2016	20	12	5	18	0	55/55%
2017	15	5	4	0	0	24/24%
2018	3	2	2	4	2	13/13%
2019	1	1	2	1	2	7/7%
2020	0	0	0	0	1	1/1%
Total/percentage	39/39%	20/20%	13/13%	23/23%	5/5%	100/100%

3.3. Economic news coverage

From 2016 to 2020, Nhan Dan (People's Daily) published 522 articles on China-related economic affairs, accounting for 42.23% of its total China-focused coverage during this five-year period and ranking first in thematic prevalence. These articles were categorized into three sub-themes: National-Level Economic Cooperation, Provincial/Municipal-Level Economic Cooperation, and VND/RMB Exchange Rate. The annual distribution of articles and their percentage representation within the economic category are detailed in **Table 4**.

Table 4. Distribution of China-related economic news on Nhan Dan (2016–2020)

Year	National-level economic cooperation	Provincial/municipal-level economic cooperation	VND/RMB exchange rate	Annual total/percentage
2016	16	11	0	27/5.17%
2017	28	20	0	48/9.2%
2018	39	13	44	96/18.39%
2019	31	14	104	149/28.54%
2020	27	6	169	202/38.7%
Total/percentage	141/27.01%	64/12.26%	317/60.73%	522/100%

Annual coverage analysis shows that from 2016 to 2020, the volume of economic news increased annually. Despite reduced coverage of bilateral economic cooperation in 2020 due to the COVID-19 pandemic, the overall trend reflects growing economic engagement between China and Vietnam. Combined with other thematic coverage, this indicates that favorable political conditions have fostered expansive economic development opportunities.

Thematic coverage analysis shows that China-Vietnam economic cooperation (39.27%): National-level cooperation dominated provincial/municipal-level exchanges; VND/RMB exchange rate (60.73%): Focused on real-time exchange rates and trend analyses.

Content analysis:

National-level economic cooperation: Articles highlighted progress and prospects in bilateral trade,

emphasizing forums, expos, and policy frameworks to enhance economic complementarity, facilitate corporate investment, and advance sustainable development.

Provincial/municipal-level economic cooperation: Coverage detailed partnerships between Vietnamese localities and Chinese regions, including Guangxi, Hunan, Yunnan, Guizhou, Ningxia, Fujian, Zhejiang, Jiangsu, Shanghai, Shandong, Guangdong, Sichuan, Chongqing, Liaoning, and China's Hong Kong, Macao, and Taiwan regions. Notable examples include Guangxi: Vietnam's largest trade partner for consecutive years, with robust cooperation in border cities (e.g., Nanning, Dongxing, Baise, Guilin) and Vietnamese provinces (Lang Son, Lao Cai, Cao Bang). Shandong: Collaborated with Vietnam on high-tech agriculture and machinery manufacturing. Hebei: Expanded cooperation in infrastructure and transportation connectivity. Chongqing: Strengthened trade and logistics ties. Hunan, Yunnan, Guizhou, Liaoning: Advanced tourism collaboration. Hong Kong: Explored cooperation in finance, shipping, electronics, and auxiliary industries.

VND/RMB exchange rate: Nhan Dan began reporting VND/RMB rates in 2018, with 317 articles (60.73% of economic coverage). This shift aligns with China's rising global influence, the RMB's growing role in international finance, and deepening Vietnam-China economic integration. Vietnam's heightened focus on RMB exchange dynamics signals recognition of China's economic weight and the currency's systemic importance.

In short, as the world's second-largest economy and top manufacturing/export hub, China's economic trajectory remains globally significant. Currently, China is Vietnam's largest trade partner and second-largest export market, while Vietnam ranks as China's top trade partner in ASEAN and sixth-largest globally. Nhan Dan's 2016–2020 coverage underscores a robust upward trend in bilateral economic cooperation. Despite COVID-19's global disruptions, China-Vietnam trade reached a historic USD 192.2 billion in 2020, marking an 18.7% annual increase. Vietnam's exports to China grew by 22.4%, reflecting resilient and mutually reinforcing economic ties. It has sustained a positive trajectory of growth. Bilateral economic and trade cooperation continues to expand in scale, elevate in structure, and diversify in scope, demonstrating expansive prospects and substantial potential. Robust economic collaboration remains a cornerstone and highlight of bilateral relations.

3.4. Science, education, culture, sports, and health news coverage

From 2016 to 2020, Nhan Dan (People's Daily) published 83 articles on China-related science, education, culture, sports, and health affairs, accounting for 6.72% of its total China-focused coverage during this period and ranking fifth in thematic prevalence. These articles were categorized into five sub-themes: Cultural affairs, Sports, Health, Education, Science and technology. The annual distribution of articles and their percentage representation within this category are detailed in **Table 5**.

Annual coverage analysis: 2018 saw the highest coverage volume (31.33%), while other years remained relatively balanced, averaging approximately 20% of the category's total. Thematic coverage analysis: Cultural affairs (59.04%): Focused on art exhibitions, literary exchanges, and youth cultural festivals, notably the China-Vietnam Youth Gala. Sports (18.07%): Highlighted bilateral sports competitions and friendly matches. Health (14.46%): Covered medical cooperation, with increased attention in 2020 to COVID-19 pandemic prevention and mutual aid in medical supplies. Education (6.02%): Reported collaborations in Marxist ideological education and professional training. Science and technology (2.41%): Detailed joint research in medicine and meteorology.

China-Vietnam exchanges in science, education, culture, sports, and health have diversified significantly,

fostering mutual understanding and strengthening the social foundation for bilateral relations.

Table 5. Distribution of China-related science, education, culture, sports, and health news on Nhan Dan (2016–2020)

Year	Cultural affairs	Sports	Health	Education	Science & tech	Annual total/percentage
2016	12	1	0	0	0	13 / 15.66%
2017	10	0	1	2	2	15/18.07%
2018	16	7	2	1	0	26/31.33%
2019	10	6	1	0	0	17/20.48%
2020	1	1	8	2	0	12/14.46%
Total/percentage	49/59.04%	15/18.07%	12/14.46%	5/6.02%	2/2.41%	83/100%

3.5. Defense and military news coverage

From 2016 to 2020, Nhan Dan published 102 articles on China-related defense and military affairs, accounting for 8.25% of total coverage and ranking third thematically. These articles were categorized into two sub-themes: Enhanced China-Vietnam Defense Cooperation, China-Vietnam Defense-Related Friendship Activities. The annual distribution is detailed in **Table 6**.

Table 6. Distribution of China-related defense and military news on Nhan Dan (2016–2020)

Year	Enhanced defense cooperation	Defense friendship activities	Annual total/percentage
2016	14	16	30/29.41%
2017	7	18	25/24.51%
2018	7	11	18/17.65%
2019	10	8	18/17.65%
2020	2	9	11/10.78%
Total/percentage	40/39.22%	62/60.78%	102/100%

Annual coverage analysis: 2016 had the highest coverage (29.41%), while 2020 saw a decline (10.78%) due to COVID-19 impacts. Thematic coverage analysis: Enhanced defense cooperation (39.22%): Included joint efforts in combating cross-border crime, drug control, border/maritime patrols, counter-terrorism drills, search-and-rescue operations, and pandemic response. Defense friendship activities (60.78%): Featured strategic security dialogues, naval visits, coast guard exchanges, and officer interactions. In summary, China and Vietnam share a commitment to regional peace and stability. Strengthening defense cooperation deepens mutual trust, preserves traditional friendship, and aligns with the long-term interests of both nations.

3.6. Miscellaneous news coverage

From 2016 to 2020, Nhan Dan published 10 articles classified as miscellaneous, accounting for 0.8% of total coverage and ranking sixth thematically. 2016 (4 articles): Covered the Red Cross Society of China's donations to Vietnamese flood victims, Vietnamese rescue of Chinese fishing boats, and China's water discharge to the Mekong River. 2018 (6 articles): Reported earthquakes in Yunnan and Hualian (China's Taiwan region) and flood disasters in both countries. Other years: No coverage.

4. Conclusion and prospects

This study analyzed the thematic distribution of China-related articles published on Nhan Dan (People's Daily) website from 2016 to 2020. Data illustrate the annual article counts, percentage representation, and overarching trends across thematic categories. The research spans 2016–2020, with a total corpus of 1,236 articles. Key findings include: Economic coverage dominated. Economic articles accounted for 42.23% of total coverage over five years, the highest among all categories, indicating the centrality of economic issues in Nhan Dan's China-related discourse. Political-diplomatic coverage remained stable. Political-diplomatic articles constituted 33.91% of total coverage, reflecting sustained attention to China's political and diplomatic affairs. South China Sea coverage declined sharply. Articles on the South China Sea decreased from 55 in 2016 to 1 in 2020, signaling diminished editorial focus on this issue. Defense-military coverage stabilized. Defense-related articles maintained an 8.25% share, demonstrating consistent reporting on military affairs.

4.1. China's national image in Nhan Dan's coverage

From 2016 to 2020, Nhan Dan portrayed China through both positive and negative lenses.

4.1.1. Positive image

The newspaper constructed China as a politically robust powerhouse with efficient governance, lauding achievements in national governance, socialist institutional reforms, and the Communist Party's leadership capabilities. A dynamic economic powerhouse, emphasizing rapid GDP growth, structural optimization, technological innovation, and advancements in infrastructure, logistics, renewable energy, and high-tech industries. Articles highlighted China's role as Vietnam's largest trade partner for 13 consecutive years and its contributions to Vietnam's socio-economic development. A benevolent neighbor, frequently reporting China's assistance to Vietnam in disaster relief (e.g., floods) and COVID-19 pandemic response (e.g., medical aid).

4.1.2. Negative image

Critical portrayals focused on two dimensions: (1) Economic concerns: Articles criticized environmental degradation linked to rapid industrialization, trade imbalances due to cheap Chinese imports crowding out Vietnamese products, and delays/safety issues in Chinese-funded infrastructure projects. (2) South China Sea disputes: Coverage accused China of “disregarding historical facts, infringing on Vietnamese sovereignty, and destabilizing regional peace” through its maritime actions, framing China as “uncompromising and irresponsible.”

4.2. Analysis of factors shaping China's image in Nhan Dan

National image is a subjective construct shaped by historical context, value systems, and cognitive biases. As Vietnam's neighbor and a regional power, China's influence has long been intertwined with Vietnam's sovereignty concerns and developmental dependencies. Vietnam's media narratives reflect this duality: (1) Positive drivers: China's global ascendancy and pragmatic cooperation (e.g., trade, aid) necessitate recognition of its achievements. (2) Negative drivers: Historical grievances (e.g., territorial disputes, asymmetric power dynamics) and anxieties over China's rise fuel skepticism. Vietnam's vigilance against perceived threats to sovereignty and autonomy amplifies critical coverage, particularly on sensitive issues like the South China Sea ^[1].

Realistic factors in negative image construction: The inherent challenges in China's domestic development process serve as foundational realities contributing to the negative shaping of its national

image. Direct factors include conflicts of interest with Vietnam in areas such as maritime territorial claims and economic-trade relations, which exacerbate the negative portrayal of China's international standing.

Sino-Vietnamese relations:

Dynamics and divergences: While China and Vietnam maintain a broad alignment in governmental stances, disparities in socioeconomic development levels persist, with China's regional influence remaining pivotal. Case studies of media coverage reveal a focus on China's political restructuring, real economic development, and international affairs management. Initiatives like the Belt and Road Initiative (B&R) and Two Corridors and One Economic Circle serve as platforms for China to advance mutual development within the globalized economy. As fellow socialist states, Vietnamese mainstream media amplify political narratives to reinforce socialist governance paradigms, drawing upon China's developmental paradigms to advance socialist agendas. Concurrently, Vietnam leverages Chinese media frameworks to stabilize ASEAN's regional economic and social governance. Geopolitical proximity facilitates bilateral exchanges but intensifies sensitivities over territorial sovereignty and economic interests. The South China Sea disputes epitomize irreconcilable tensions between safeguarding national sovereignty and pursuing diplomatic strategies.

Vietnam's strategic narratives: Vietnam actively promotes the ASEANization and internationalization of South China Sea disputes, seeking to consolidate regional and global consensus discourse to constrain China's maritime diplomacy. By sustaining public and international attention on these issues, Vietnam aims to counterbalance China's strategic maneuvers while reinforcing its own claims through multilateral frameworks ^[2].

The current ecosystem of international discourse is marked by exceptional complexity, with Western media dominating its trajectory. Western outlets habitually frame their coverage of other nations through preconceived ideological lenses, while the protracted ideological oppositions between East and West have cemented a dominant tone in Western media narratives ^[3].

"Westernization," "fragmentation," "splittism," and the "China Threat Theory" constitute its defining characteristics ^[4].

The image of China depicted in media coverage across various platforms is inevitably subject to certain degrees of influence. Additionally, "collisions of diverse interests, shifts in the political landscape, and the triggering of hotspot issues or events" collectively constitute factors driving changes in media attitudes toward China ^[4].

For Vietnamese media, the benchmark of interpretative deviation does not lie in ideological infiltration but in their subjective presumption of the "China Threat Theory" and external incentive interference. Conflicts of interest, value orientations, and localized hotspot issues have intensified contradictions between China and Vietnam. Media cannot escape their inherent perspectives, stances, and ideologies, inevitably resulting in deliberate or inadvertent misinterpretations and inductions. Through the lens of Agenda-Setting Theory, Nhan Dan (People's Daily) strategically selects and arranges news themes to manipulate public attention in Vietnam, thereby shaping the public's preliminary perception of China's national image and laying the cognitive foundation for mass understanding.

4.3. Implications of Nhan Dan's research on China's national image

It can be argued that the construction of China's national image is inevitably influenced by Vietnamese media's subjective framing while simultaneously depending on China's proactive developmental strategies and actions. Despite historical complexities between China and Vietnam, a robust cooperative foundation

conducive to bilateral development persists. In the contemporary era (as of April 20, 2025), marked by profound and intricate shifts in regional and global dynamics, China and Vietnam share pragmatic imperatives for mutual development. Therefore, consolidating and strengthening the good-neighborly friendship and comprehensive cooperation aligns with the fundamental and enduring interests of both peoples, while also contributing to regional and global peace and stability.

Currently, China is actively advancing the Belt and Road Initiative and the Two Corridors and One Economic Belt, enhancing political trust through high-level exchanges. It promotes Sino-Vietnamese economic and trade activities in diversified formats, constructs new frameworks of interest convergence, and achieves reciprocal development. By addressing the South China Sea disputes judiciously, fostering an atmosphere of amicable cooperation, and steering bilateral relations toward positive trajectories, China gradually ameliorates Vietnam's negative perceptions.

The rise of China's political and economic stature, coupled with its amplified international discourse power, constitutes an inescapable theme in foreign media's portrayal of China. Vietnamese media perceives China as both a pivotal economic and trade partner and a latent competitor entangled in international disputes. China's proposed concepts, such as the "Community of Shared Future for Mankind" and "Global Governance," serve as compelling evidence of its commitment to national equality and universal human values ^[5].

Seeking common ground while shelving differences, co-consultation, co-construction, and shared development among nations, alongside the fulfillment of concrete national responsibilities and obligations, will serve as an effective pathway to resolving conflicts and contradictions.

The efficacy of international communication hinges, to a certain extent, on the audience's recognition of news content. Telling China's stories well, safeguarding China's image in service of the people, promoting cultural mutual learning, and fostering global harmony have emerged as universally accepted entry points. In contrast, Vietnamese media's "Othering" lens—which facilitates self-understanding through mirroring, focuses on the deconstruction and reconstruction processes among the Vietnamese populace—will enrich the connotations of China's image, enhance the effectiveness of news media in international communication, and thereby cultivate a more inclusive and amicable international public opinion environment. This approach facilitates the multidimensional construction of a national image imbued with ethnic distinctiveness and epochal characteristics.

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Research on the Digital Transformation and Cross-Cultural Communication of Traditional Chinese Medicine Education System in the Context of Global Standardization

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Abstract: This study examines the digital transformation of traditional Chinese medicine (TCM) education within the context of global standardization, along with the challenges and opportunities of its cross-cultural dissemination. With the rapid advancement of technologies such as artificial intelligence, virtual reality, and blockchain, TCM education is experiencing a significant disruption and innovation of its traditional models. The research develops a “Standard-Technology-Culture” tri-spiral model to analyze how TCM education can achieve a seamless integration of standardization, technological innovation, and cultural preservation during its globalization process. The study finds that standardization provides the foundation for TCM education’s global expansion, while technological innovation drives the transformation of educational methodologies. Simultaneously, cultural preservation ensures the distinctiveness of TCM education. However, the tension between standardization and the unique characteristics of TCM, as well as the balance between technological empowerment and cultural transmission, remain critical challenges in the ongoing transformation. Based on these findings, the study proposes strategies such as the “digital apprenticeship” model and blockchain-based certification systems to advance the globalization and digital transformation of TCM education, providing theoretical support for the creation of a global health community.

Keywords: TCM education; Digital transformation; Global standardization; Cross-cultural communication; Technological innovation

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1. Introduction

With the continuous advancement of globalization, countries around the world are increasingly moving towards standardization and digitalization in the field of medical education. In particular, traditional Chinese medicine (TCM), as an essential component of Chinese traditional culture, faces unprecedented opportunities and

challenges in its educational model. Deeply rooted in Chinese cultural traditions, TCM has gradually gained attention from an increasing number of countries and regions worldwide.

The World Health Organization (WHO) has incorporated TCM into the global medical education framework, signaling the beginning of its internationalization process ^[1]. Meanwhile, the rapid development of digital technologies, especially the application of cutting-edge technologies such as artificial intelligence (AI) and the Metaverse ^[2], is disrupting traditional medical education models, providing vast opportunities for the digital transformation of TCM education ^[3].

However, despite the dual opportunities presented by globalization and digital transformation, the challenges of cross-cultural communication remain significant. Cultural differences create various constraints for TCM in its international dissemination ^[4]. How to achieve the standardization and digital transformation of TCM education while preserving its unique cultural characteristics in the context of globalization has become a critical issue to address. This study explores the potential pathways for the digital transformation and cross-cultural communication of TCM education under the global standardization framework, revealing the challenges and opportunities involved. The study constructs a “Standard-Technology-Culture” three-dimensional analytical model to uncover the deeper contradictions and developmental pathways of TCM education’s internationalization, providing theoretical support for the creation of a global health community.

2. Multi-dimensional construction of international standards for TCM education

In the global context, TCM education’s internationalization progresses gradually. However, standardization efforts still encounter various obstacles ^[5]. The standardization process not only affects how TCM education is positioned within international medical systems but also influences its cross-border dissemination and practical applications ^[6]. Therefore, comprehensively evaluating current standardization status and understanding global system dynamics becomes essential, as this forms the basis for discussing digital transformation and cross-cultural communication challenges.

2.1. Analysis of international standard systems

Key international organizations like ISO and WHO play pivotal roles in TCM education standardization ^[7]. For instance, WHO’s “Traditional Medicine Education Framework” provides reference guidelines for regulating traditional medicine education globally. That being said, global standardization remains a continually improving and evolving process rather than a completed task.

2.1.1. Interpretation of core indicators in WHO’s education framework

The WHO’s “Traditional Medicine Education Framework” broadly lays out the main standards for education in this field, covering aspects like curriculum design, how to teach, training teachers, and clinical practice work ^[8]. That is to say, these standards aim to guide different nations in their traditional medicine education efforts, promoting better acceptance across medical systems. For Chinese medicine specifically, the framework requires educational content to preserve its unique characteristics while meeting modern medical education criteria. Simply put, this means combining theoretical knowledge with hands-on practice through interdisciplinary teaching approaches ^[9].

2.1.2. Progress of ISO international standard for traditional Chinese medicine

When looking at global standardization efforts, the technical committee working on TCM standards under the

International Organization for Standardization (ISO) has been crucial to developing international guidelines ^[10]. This committee has created multiple standards related to diagnosis methods, treating patients, and product quality requirements ^[11]. The creation of these standards has pushed forward international certification processes for Chinese medicine, improving how it is viewed worldwide. To put it simply, this helps build trust in Chinese medicine practices across different countries.

2.1.3. Comparison of acupuncturist certification systems in Europe and the United States

In examining certification systems for acupuncture practitioners, Europe and North America show varied approaches. The United States manages certifications through its national commission that sets education criteria and evaluation processes ^[12,13], while the United Kingdom's system operates under a different oversight body ^[14]. These differences in certification rules, what education is needed, and hours spent in clinics reflect how regions have unique needs in standardizing Chinese medicine education. By comparing these systems, we can identify useful patterns for creating globally recognized standards.

2.2. Practical cases of digital education

With digital technologies advancing, more educational programs now use online platforms and virtual tools to update teaching methods. This shift helps standardize Chinese medicine education by making training materials more consistent and accessible, though challenges remain in maintaining practical skill development through digital means ^[15].

2.2.1. Virtual TCM clinic teaching system

The so-called “Cloud Clinic” initiative serves as a representative case of virtual teaching platforms in traditional Chinese medicine education ^[16]. Through digital simulation technology that mimics real-world scenarios, this system recreates diagnostic processes online, enabling learners to practice treatment decisions using virtual patient cases when actual clinical opportunities are scarce. This approach not only focuses on enhancing practical skills but also gives students from different regions a way to learn TCM diagnostic methods globally. By adopting such digital education tools, the standardization and international spread of teaching materials has become more feasible through technical means.

2.2.2. Application of blockchain technology in educational certification

The adoption of distributed ledger systems for academic credential management has gradually emerged as a development trend ^[17]. Taking the Malaysian TCM education credit repository as an example ^[18], this project utilizes blockchain mechanisms to track student learning progress and academic achievements, thereby ensuring data authenticity and permanent preservation features. To put it simply, this creates a secure record that is hard to alter, offering novel solutions for certification systems in TCM training. Through such technological interventions, global mutual recognition of educational qualifications could potentially be realized, thereby accelerating the standardization process in TCM education through digital pathways.

2.2.3. AI-assisted tongue and pulse diagnosis training platform

The experimental “Look, Listen, Ask, Feel” project at Tianjin University of TCM has developed an intelligent training system for diagnostic skill development ^[19]. By employing smart algorithms that imitate traditional diagnostic procedures, the platform assists in simulating tongue examination and pulse reading processes, allowing learners to gain certain diagnostic skills faster through repeated practice sessions that adjust to

their progress. Unlike conventional apprenticeship models, this digital method provides customized learning trajectories while offering immediate feedback on practice outcomes. Such AI-enhanced teaching approaches not only improve educational efficiency but also ensure consistent teaching quality through standardized evaluation features.

2.3. Empirical evidence of the dilemma of cultural communication

The international dissemination of TCM is not only a matter of education, but also of cultural dissemination. The TCM system itself has strong Chinese cultural characteristics, which makes it face many cultural differences in the process of spreading and accepting it overseas.

2.3.1. Survey on standardization of terminology translation

The difference in the translation of TCM terminology between different languages is a core issue in the international dissemination of TCM. Taking the English translation of the *Yellow Emperor's Neijing* as an example, there are differences in the translation of TCM terminology in different translations, which affect the understanding and acceptance of TCM concepts by overseas students^[20]. A comparative analysis of six different English translations of the *Yellow Emperor's Neijing* shows that the standardization of terminology translation is crucial for the accurate dissemination of TCM^[21].

2.3.2. Research on cognitive biases of overseas students

According to the survey and analysis of 1,000 cross-border questionnaires, it was found that overseas students had a large deviation in their understanding of TCM concepts such as “Yin and Yang Five Elements”^[22]. These deviations are mainly due to cultural differences and language barriers, which lead to misunderstandings in students' understanding of TCM, which affects their learning and practical application. The study of cognitive biases of overseas students can provide effective countermeasures for Chinese medicine education and promote the improvement of cross-cultural teaching.

2.3.3. Analysis of the completion rate of international MOOC courses

As a form of online education, MOOCs have become an important channel for TCM education around the world. However, according to data from the Coursera platform, the dropout rate of TCM courses is as high as 67%^[23]. This problem reflects the shortcomings of international TCM education in terms of curriculum design, cultural adaptability, and teaching content. Analyzing the completion rate of MOOC courses can provide a strong basis for improving TCM education^[24].

3. Core contradictions and transformation bottlenecks

The digital transformation and internationalization of TCM education have brought many opportunities, yet in practice, they still face various core contradictions and transformation bottlenecks^[25]. To put it simply, these challenges involve not just the conflict between standardization and the special features of TCM education but also tensions between technology-driven progress and cultural preservation. Additionally, there is the issue of international certification losing its original context, conflicts with TCM's overall approach to treatment, and structural obstacles in cross-cultural communication. An in-depth analysis of these contradictions and bottlenecks helps us better grasp the challenges in transforming TCM education and offers theoretical support for future reforms^[26].

3.1. Conflict between standardization and unique characteristics

For instance, the international development of TCM education needs its system to move toward standardization to fit into global medical education. However, being a traditional medicine with thousands of years of history, TCM's theories, how diagnoses are made, and its educational structure all carry strong Chinese cultural elements. This rich cultural background, in other words, clashes with the standardization demands of global medical systems ^[27]. Balancing TCM's distinct identity with international standardization requirements remains a central contradiction in its global expansion ^[28].

3.1.1. Pressure of international standardization

The pressures from international standardization mainly impact areas like what is taught in the curriculum, assessing educational quality, and training teachers. International bodies such as the WHO and ISO have set up basic frameworks for traditional medicine education ^[8,10]. However, these frameworks tend to follow Western medical standards, missing key parts specific to TCM education. For example, the master-apprentice learning model, the overall approach to thinking, and the methods of dialectical treatment. Standardization tries to measure educational content, focusing on passing on knowledge, whereas TCM education values combining theory with practice and passing knowledge through close mentorship. This leads to a big clash with the measurable assessment criteria required by standardization ^[29].

3.1.2. Persistence of TCM's unique characteristics

Efforts to maintain TCM's uniqueness face challenges when adapting to international norms. That is to say, features like personalized treatment strategies and context-dependent diagnostic practices resist easy categorization. While modern education systems prioritize replicable teaching formats, TCM's knowledge transmission relies heavily on experiential learning and cultural immersion. This persistence creates friction during quality evaluations, particularly when using standardized metrics designed for Western biomedical education models.

Traditional Chinese medicine education acts not only as academic training but also functions as a cultural inheritance. In traditional TCM educational practices, considerable emphasis is placed on the mentor-disciple dynamic, prioritizing customized instruction and gradual buildup of hands-on expertise. To put it simply, conventional teaching models emphasize adaptability and practice-heavy methods, while international standardization frameworks demand rigid curricula and uniform assessment mechanisms. The central dilemma revolves around preserving TCM's distinctive educational characteristics while adapting to global standardization demands.

3.2. Impacts of quantitative evaluation systems on the deconstruction of the “master-apprentice experience”

Within TCM pedagogy, the “master-apprentice experience” serves as a foundational approach for transmitting knowledge and cultivating clinical competencies ^[30]. Modern educational systems, by contrast, depend on measurable evaluation tools—such as grading coursework, analyzing exam performance, and implementing credit accumulation systems—to assess learner progress. These methods, however, frequently overlook the slow cultivation of experiential wisdom and situation-specific problem-solving abilities gained through prolonged practice. Traditional TCM training enables learners to integrate theoretical knowledge with clinical skills through years of close mentorship, whereas modern quantitative systems prioritize numerical scoring over holistic skill development. This fundamental mismatch creates tension between apprenticeship-centered

education and data-driven evaluation frameworks ^[31].

3.2.1. The “quantitative bias” of modern education

Contemporary education systems predominantly focus on knowledge dissemination and converting learning outcomes into numerical metrics, often sidelining the organic growth of practical capabilities ^[32]. For instance, diagnostic techniques like interpreting tongue coatings or assessing pulse patterns—which require years of supervised practice—become reduced to theoretical test questions under quantitative evaluation. Similarly, formulating personalized treatment plans based on symptom patterns resists straightforward scoring mechanisms. Despite being central to TCM practice, such competencies remain poorly reflected in standardized assessments that prioritize textbook memorization. This overreliance on quantifiable metrics inadvertently marginalizes the irreplaceable role of mentorship and clinical immersion within TCM education.

3.2.2. The challenge of quantifying practical experience

The difficulty lies in translating intangible educational outcomes like a practitioner’s diagnostic intuition or treatment adaptability into numerical values. While modern systems excel at tracking exam scores and course completion rates, they struggle to measure how effectively students internalize clinical decision-making processes through mentor guidance. For example, the nuanced ability to adjust herbal prescriptions based on subtle symptom shifts relies heavily on observational learning and iterative feedback, aspects that resist modular evaluation formats. This discrepancy highlights systemic limitations in assessing educational models where experiential knowledge transmission remains paramount.

The core approaches of TCM, such as diagnosis through observation, listening, inquiry, and palpation, are typically developed through years of hands-on practice and guidance from experienced practitioners ^[33]. However, current ways of measuring progress in education systems do not quite capture how these unspoken skills develop over time ^[34]. The challenge remains in how to document and pass down this mentorship knowledge through modern teaching tools and evaluation frameworks, while preventing oversimplification that could limit deeper understanding of TCM education. There exists a tension between preserving traditional learning methods and meeting modern standardization requirements.

3.3. Conflicts when international standards remove cultural context

Global certification systems demand TCM education to follow uniform benchmarks for worldwide recognition ^[35]. Yet TCM’s foundational philosophy stresses viewing the body as an interconnected system, focusing on personalized treatment approaches that differ significantly from Western medicine’s localized problem-solving and standardized protocols ^[36]. International frameworks often prioritize common standards, which inadvertently neglect the cultural and theoretical roots embedded in TCM education.

3.3.1. Issue of cultural disconnection

TCM teaching content draws deeply from Chinese cultural traditions, but during global certification processes, these contextual elements often get stripped away. Many international systems push for curriculum structures resembling Western medical education—emphasizing compartmentalized subjects and teaching universal knowledge. This creates misalignment with TCM’s emphasis on flexible treatment strategies tailored to individual needs. When cultural and philosophical foundations are removed, there is a risk of fragmented interpretation and teaching practices that miss the essence of TCM’s holistic principles ^[37].

3.3.2. Limitations of integrated perspectives

The unified approach central to TCM struggles to fit into assessment models favoring isolated skill evaluation. For instance, standardized testing frameworks tend to measure diagnostic capabilities separately rather than as part of dynamic patient interactions. This mismatch raises concerns about whether international certification can truly validate the nuanced competencies developed through traditional TCM training methods.

TCM's comprehensive methodology demands treatment plans integrating multiple considerations such as patient physical condition, environmental factors, and psychological aspects, resulting in highly customized care approaches ^[38]. In the context of global integration, certification systems now require standardized treatment guidelines across regions, thereby restricting how TCM's whole-body philosophy can operate within rigid frameworks ^[39]. Maintaining TCM's individualized treatment characteristics and complete health perspective within international medical education systems continues to present unresolved difficulties.

3.4. Tension between technological empowerment and cultural transmission

The accelerated development of digital tools, particularly implementations involving artificial intelligence (AI), virtual reality (VR), and Metaverse concepts, has introduced novel educational possibilities for TCM training ^[2]. However, these technological advancements have simultaneously created friction with the cultural dimensions embedded in TCM instruction ^[3]. That is to say, TCM education encompasses not merely knowledge transfer but also involves transmitting cultural philosophies and value systems. Overemphasis on technological solutions risks diminishing the human-centered ethos and mentor-apprentice dynamics fundamental to TCM learning traditions.

3.4.1. The double-edged sword effect of VR and AI

VR and AI applications can substantially enhance educational efficiency in TCM studies. For example, machine-assisted diagnostic tools enable faster mastery of pulse reading and tongue analysis techniques. Yet excessive reliance on such instruments may reduce direct patient interaction opportunities, potentially weakening trainees' compassionate care capacities and emotional intelligence ^[40]. Critical elements like medical ethics education and practitioner-patient rapport building might become neglected within technology-dominated teaching models.

3.4.2. Balancing technology and tradition

The central challenge within TCM education modernization lies in harmonizing technological integration with cultural legacy preservation. Simply put, we must ensure innovation tools do not erode foundational teachings. While pursuing digital transformation, educational institutions should simultaneously emphasize TCM's historical wisdom and philosophical depth, ensuring students inherit both practical skills and the cultural essence ^[41]. This involves protecting time-honored teaching relationships while selectively adopting technological aids that complement rather than replace humanistic values.

4. Pathways for digital transformation

In the context of globalization, the digital shift in TCM education becomes a crucial pathway for addressing standardization demands, cultural exchange barriers, and innovating curriculum content. With the swift advancement of tech tools, traditional teaching models are undergoing significant transformations. The challenge lies in how to balance technological adaptation with heritage preservation, leveraging digital methods

to modernize education, while protecting cultural authenticity remains an urgent priority requiring coordinated efforts.

4.1. Integration of educational technology and innovation

The evolution of TCM education necessitates blending technological advancements with instructional materials. Emerging technologies such as data analytics, smart algorithms, immersive simulations, and secure data systems have altered teaching approaches, learning resources, and evaluation frameworks. To put it simply, TCM educators must adapt these tools to create hybrid models that honor traditional practices while embracing modern digital trends ^[42].

4.1.1. Digital twin TCM hospital

The “digital twin” concept refers to a method connecting real and virtual environments through mirrored systems, enabling dynamic interaction between physical and simulated spaces. In practical terms, this technology allows learners to practice diagnostic procedures within simulated clinic settings. Through immersive digital environments, students can engage in time-flexible training sessions, overcoming geographical limitations. For instance, trainees might conduct virtual consultations using traditional diagnostic techniques like observation and pulse assessment, thereby refining clinical competencies without physical constraints.

4.1.2. Intelligent deconstruction of ancient TCM books based on NLP

Ancient books of Chinese medicine are a valuable heritage of Chinese medicine knowledge, but they are difficult to learn due to their ancient language and obscure expressions. The application of natural language processing (NLP) technology can help solve this problem in TCM education ^[43]. Through NLP technology, ancient Chinese medicine books can be intelligently deconstructed, medical knowledge, prescriptions, and treatments can be extracted, and translated and expressed according to the language of modern medicine ^[44]. Through NLP technology, the prescriptions, diagnoses, and treatment methods in classic TCM works such as *Treatise on Typhoid Fever* and *Huangdi Neijing* can be transformed into standardized medical terminology to help students better understand and master TCM knowledge. This technology can not only modernize the classical knowledge of traditional Chinese medicine but also help students quickly obtain relevant information through intelligent search and data analysis, and improve learning efficiency.

4.2. Cross-cultural communication strategies

The global dissemination and international acceptance of TCM education requires effective cross-cultural communication frameworks. Given the substantial conceptual differences between traditional Chinese medical philosophy and Western biomedical paradigms, addressing these cognitive divergences becomes crucial for facilitating worldwide educational expansion.

4.2.1. Establishing a “three-level translation” system

The deeply culturally embedded concepts and specialized terminology within TCM pose significant translation challenges. To overcome these barriers, an integrated translation methodology should be implemented, containing ^[45]: (1) Cultural interpretation layer ^[46]: Adapting foundational concepts like Yin-Yang theory and meridian systems into Western cultural reference frameworks through explanatory analogies. (2) Conceptual translation tier ^[47]: Transforming diagnostic theories such as “Qi deficiency patterns” into biomedical-equivalent

physiological descriptions using contemporary scientific vocabulary. (3) Standardization phase: Aligning therapeutic techniques like acupuncture manipulation with globally recognized medical practice guidelines through procedural equivalence mapping. Through this layered translation mechanism, the cultural and cognitive obstacles inherent in TCM education can be systematically addressed, producing more accessible international educational resources.

4.2.2. Developing contextualized educational tools

Interactive learning systems incorporating scenario-based simulations demonstrate particular effectiveness for conveying TCM's holistic diagnostic approaches^[48]. By recreating classical case studies through virtual patient scenarios, learners can practice syndrome differentiation techniques within controlled environments. These digital platforms allow students to apply pulse diagnosis methods and herbal prescription strategies while receiving immediate feedback on their diagnostic reasoning processes. Such immersive educational tools not only improve knowledge retention but also help bridge the gap between theoretical learning and clinical application.

Contextualized educational games, utilizing game-based learning approaches, assist students in comprehending intricate subjects through simulated environments. For TCM education, this translates to creating interactive experiences such as “Five Elements Parkour” or “Meridian Maze,” where learners encounter foundational theories and therapeutic techniques within virtual settings. These activities enable students to absorb essential TCM principles in an engaging manner while simultaneously developing clinical reasoning abilities through scenario-based challenges, merging theoretical knowledge with practical application.

4.2.3. Establishing a global TCM MOOC alliance

Regarding the expansion of digital education platforms, worldwide MOOC-based learning has emerged as a significant educational format. Establishing a global TCM MOOC alliance serves as a crucial mechanism for advancing educational modernization. This collaborative framework would promote cross-border resource sharing, facilitate reciprocal credit recognition between institutions, and implement multilingual translation services, thereby reducing location-based and language barriers while broadening access to TCM studies. Furthermore, the alliance could employ sophisticated data analysis tools and intelligent systems to monitor learner progress dynamically, delivering tailored content recommendations to optimize instructional outcomes, enhancing both reach and relevance.

4.3. Breakthrough in standardization construction

While promoting the digital transformation of TCM education, standardization is still the core issue in the process of globalization. How to establish a set of educational standards that meet international requirements and retain the characteristics of traditional Chinese medicine is an important task for traditional Chinese medicine education.

4.3.1. Design of the competency-based education framework for TCM

The competency-based education framework (CBE) is an educational model that focuses on students' competency development, which designs a systematic curriculum system and learning evaluation standards based on the core competencies of TCM^[49]. The construction of the competency-based education framework enables students to master the basic theories and techniques of traditional Chinese medicine, and cultivate their

clinical decision-making ability, comprehensive analysis ability, and teamwork ability.

4.3.2. Dynamic digital badge authentication system

The digital badge certification system represents an educational certification approach built on blockchain technology, which enables recording learning progress, tracking clinical experiences, and certifying academic achievements through blockchain-based storage ^[50]. To put it simply, this method creates a transparent record of educational milestones while supporting secure sharing across institutions. By utilizing this distributed verification mechanism, the system enhances credibility in traditional medicine education and facilitates global recognition of qualifications.

4.3.3. Establishing an AI middle platform for monitoring the quality of TCM education

Regarding quality assurance, establishing monitoring tools powered by artificial intelligence has become crucial for maintaining educational standards. These AI systems can track certain important quality indicators in real-time monitoring, such as curriculum update frequency, teaching evaluations, and how students are progressing in their studies ^[51]. Continuous oversight helps identify potential gaps in the educational process, allowing for timely adjustments. This approach enables institutions to address issues before they escalate, thereby improving overall program quality through proactive interventions ^[52].

5. Policy support and ecological construction

5.1. National level

At the policy level, advancing digital transformation in traditional medicine education requires coordinated efforts across governmental and industrial sectors. National strategies should focus on creating supportive frameworks through policy direction and resource allocation. For instance, integrating digital education initiatives into broader international cooperation programs could foster cross-border collaboration. By developing comprehensive policies that encourage technological adoption while preserving cultural heritage, stakeholders can build an ecosystem conducive to sustainable growth. This involves not only regulatory support but also cultivating partnerships between educational institutions and technology providers to drive innovation in teaching methodologies.

5.1.1. Including digital TCM in the special project for the construction of the “Digital Silk Road”

The “Digital Silk Road” stands as one of China’s key strategies in the global digital economy field, focusing on pushing forward the building of worldwide digital infrastructure and collaborative efforts, which help blend international digital economy activities. By including digital TCM approaches within this initiative, not only would it assist in advancing the digital transformation of TCM education through technical exports, but also encourage the spread of TCM culture globally, creating mutual benefits across nations ^[53]. Through such measures, authorities could back the development of digital platforms related to TCM education, thereby boosting the adoption and dissemination of digital methods in TCM across various regions. This might involve creating educational resource platforms and online learning systems that offer TCM courses and remote clinical guidance, among other services, to learners worldwide. Moreover, via collaborative international efforts, support could be provided to developing nations and areas to set up their own TCM education frameworks, which would enhance the worldwide promotion and growth of TCM practices.

5.1.2. Establishment of the Institute of International Standards for Chinese Medicine Education

The process of internationalizing TCM education requires standardization; without unified standards, progress remains challenging. To facilitate this, the government might consider forming an International TCM Education Standards Research Institute, tasked with studying and developing educational benchmarks. This institute could work alongside academic institutions, education organizations, and government bodies both domestically and abroad to conduct standardization research, ultimately creating education standards and certification systems that hold international appeal. Key responsibilities would include establishing standards covering curriculum design, teaching approaches, and educator training, ensuring TCM education meets global expectations while preserving its traditional essence. Additionally, partnerships with international organizations could promote the recognition and application of these standards globally, offering theoretical support for TCM education's international reach.

Another proposed measure involves advocating for the creation of a WHO Traditional Medicine Education Digital Certification Center. Such a center would focus on developing digital certification processes for TCM education programs, enhancing credibility, and facilitating international acceptance of TCM qualifications. By collaborating with health authorities and educational institutions, the center could establish evaluation criteria and certification mechanisms applicable across different countries and regions. This initiative would not only standardize the quality of TCM education but also strengthen its position within global healthcare systems, thereby contributing to the broader integration of traditional medicine practices worldwide.

5.1.3. Promoting the establishment of the WHO Digital Accreditation Center for Traditional Medical Education

The WHO has incorporated traditional medicine into global healthcare frameworks ^[54], promoting standardization and certification processes for related education systems. As a key component within international traditional medicine practices, TCM should actively take part in building global certification mechanisms. Governments should advocate for creating a WHO-affiliated Digital Certification Center for Traditional Medicine Education, which would manage digital accreditation tasks specifically for TCM education programs.

This center would offer digital validation services for TCM training courses, ensuring educational quality aligns with international benchmarks. The certification system could utilize advanced technologies such as secure digital ledgers to verify academic credits, instructor qualifications, and related criteria, thereby ensuring transparency and reliability in certification records. To put it simply, this center would not only assist in spreading TCM education globally but also enhance its standardization and alignment with international practices.

5.2. Industry collaboration

The involvement and backing of industry stakeholders remain vital for advancing the digital transformation of TCM education. Collaborative efforts across sectors can drive innovation in technology, provide access to resources, and facilitate market expansion, all of which are essential for progressing TCM education's digital shift. Governments, businesses, and educational institutions must work together closely to enable this transformation.

5.2.1. Establishing a multinational TCM education technology alliance

Digital transformation requires both technological infrastructure and cross-sector partnerships ^[55]. International

cooperation can help overcome barriers to the globalization of TCM education. Governments could encourage the formation of a multinational alliance focused on TCM education technologies, enabling coordinated efforts across supply chains to jointly advance tech innovations and knowledge dissemination.

5.2.2. Developing an open-source TCM digital tools platform

Creating an open-access platform for TCM-related digital tools represents another critical step in supporting its educational digitization. Governments might support the development of such a platform, offering freely available training resources based on core TCM diagnostic methodologies. This platform would not only provide intelligent learning aids but also simulate clinical scenarios and treatment planning, thereby improving students' overall skills through practical exposure.

The advancement of such open-access platforms could make it easier to share TCM educational resources globally, offering technical assistance for spreading TCM education internationally ^[56]. These platforms may attract worldwide developers to participate in features like algorithm innovations, which could further push forward the digital changes in TCM education.

5.3. Cultural security mechanisms

Regarding cultural protection mechanisms, it should be noted that TCM is not just medical knowledge but also a key piece of China's cultural heritage. During the global expansion of TCM education, emphasis should be placed on safeguarding cultural information from being altered improperly or used wrongly. To put it simply, establishing comprehensive systems for protecting digital resource ownership and cultural identification becomes particularly vital.

5.3.1. Establishing a sovereign protection system for digital resources of traditional Chinese medicine

With the advancement of the digital transformation of TCM education, more and more TCM resources are stored and disseminated in digital form, including TCM classic literature, teaching content, diagnosis and treatment data, etc. These digital resources have high academic and cultural value, and how to protect these resources from abuse, misappropriation, or malicious tampering has become an important task in the digital education of traditional Chinese medicine ^[57].

The government may establish a sovereign protection system for digital resources of traditional Chinese medicine through legislation or policies, and clarify the ownership, use, and management rights of digital resources of traditional Chinese medicine. By formulating relevant policies, we will ensure that the digital resources of TCM will not be misused or maliciously plagiarized. At the same time, blockchain and other technical means are used to ensure the security and immutability of digital resources and provide security for the digital transformation of traditional Chinese medicine education.

5.3.2. Constructing a genetic identification system for TCM culture

Traditional Chinese medicine is not only a medical system, but also one of the representatives of Chinese culture. In the process of globalization, how to protect the intellectual property rights of traditional Chinese medicine culture to avoid its misinterpretation or abuse is an urgent problem to be solved. Constructing a genetic identification system for TCM culture to provide an independent cultural identity and intellectual property anchor for TCM culture can ensure that it is not infringed upon in the process of global dissemination ^[58].

Constructing a genetic identification system for TCM culture can provide a legal guarantee for TCM

education and cultural dissemination. The TCM cultural gene identification system can provide a digital chain of evidence for the intellectual property rights of TCM and maintain the independence and integrity of TCM culture. From acupuncture and moxibustion to AI diagnosis and treatment systems, building an intellectual property protection system for traditional Chinese medicine can ensure the authenticity and cultural security of traditional Chinese medicine culture.

6. Conclusion

This study thoroughly explores the digital transformation of TCM education in the context of global standardization, analyzing the opportunities and challenges brought about by this transformation. With the continuous development of technologies such as AI, VR, blockchain, and the Metaverse, TCM education is undergoing an unprecedented revolution. These technologies not only break through the temporal and spatial limitations of traditional education but also greatly enhance the accessibility and efficiency of learning, offering new opportunities for the inheritance and innovation of TCM culture.

Through this research, we have proposed and validated the “Standard-Technology-Culture” tri-spiral development model, emphasizing the need for the digital transformation of TCM education to integrate standardization, technological innovation, and cultural preservation. Standardization provides the foundation for the globalization of TCM education, enabling it to align with international educational systems and secure a place in global medical education. Technological innovation provides strong support for the teaching models, content, and methods of TCM education, driving a revolution in educational formats. Cultural preservation ensures the uniqueness of TCM education, making it not only a part of medical education in the global context but also a key element of China’s cultural soft power.

The future development of TCM education will depend on the organic integration of standardization, technological innovation, and cultural preservation. This integrated transformation model will not only facilitate the global spread of TCM but also provide an important theoretical basis and practical pathway for the creation of a global health community.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Reform of Assessment Methods for Core Courses of the Traffic Engineering Specialty

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Abstract: This paper deeply analyzes the characteristics of core courses of the traffic engineering specialty and the problems existing in traditional assessment methods, and proposes a series of reform measures for the assessment methods of core courses of the traffic engineering specialty. By introducing diversified assessment methods, focusing on process assessment, and strengthening the assessment of practical abilities, the aim is to improve students' learning enthusiasm and initiative, and cultivate students' innovation ability and practical ability to meet the needs of traffic engineering professionals in the new era.

Keywords: Traffic engineering specialty; Core courses; Reform of assessment methods; Course characteristics; Process assessment

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1. Introduction

Traffic engineering specialty is a relatively comprehensive discipline, involving multiple fields such as traffic planning, traffic management, traffic safety, and traffic design. Core courses are an important part of traffic engineering specialty teaching and play a crucial role in cultivating students' professional qualities and practical abilities ^[1]. However, traditional assessment methods often have problems such as emphasizing theory over practice and results over process, making it difficult to comprehensively and accurately evaluate students' learning achievements and ability levels. Therefore, reforming the assessment methods for core courses of the traffic engineering specialty has important practical significance ^[2].

2. Characteristics of core courses of the traffic engineering specialty

2.1. Strong comprehensiveness

Core courses of the traffic engineering specialty cover knowledge in multiple disciplinary fields such as engineering mechanics, traffic planning, traffic management, and traffic safety ^[3]. Students need to have a solid foundation in basic knowledge such as mathematics, physics, and computers, and need to master the basic theories and methods of the traffic engineering specialty ^[4].

2.2. Strong practicality

Traffic engineering specialty is an applied discipline, and the teaching content of core courses is closely combined with practical engineering ^[5]. Students need to apply theoretical knowledge to practical problems through practical links such as experiments, course designs, and internships to improve their practical and problem-solving abilities ^[6].

2.3. High demand for innovation

With the continuous development of traffic technology and the increasing complexity of traffic problems, the traffic engineering specialty needs continuous innovation and development. The teaching content of core courses needs to keep up with the times and cultivate students' innovative thinking and innovation ability to meet the development needs of the traffic engineering field in the future ^[7].

3. Problems of traditional assessment methods

3.1. Single assessment method

Traditional assessment methods mainly rely on final exams, and the proportion of usual grades is relatively small. This assessment method overly focuses on students' mastery of theoretical knowledge and neglects the cultivation of students' practical ability, innovation ability, and comprehensive quality.

3.2. Emphasizing results over process

Traditional assessment methods often only pay attention to students' exam scores and neglect their learning process. In order to achieve good grades, students may adopt rote learning methods and lack in-depth understanding and mastery of knowledge. At the same time, this assessment method is also not conducive to teachers' understanding of students' learning situation in time, and adjusting teaching methods and progress.

3.3. Insufficient assessment of practical ability

The core courses of the traffic engineering specialty have strong practicality, but traditional assessment methods often do not pay enough attention to the assessment of practical ability ^[8]. The assessment methods of practical links are usually relatively simple and difficult to comprehensively and accurately evaluate students' practical ability and innovation ability ^[9].

3.4. Lack of evaluation of students' comprehensive quality

Traditional assessment methods mainly focus on students' mastery of professional knowledge and lack effective evaluation means for students' comprehensive qualities such as teamwork ability, communication ability, and innovation ability.

4. Measures for reform of assessment methods

4.1. Diversified assessment methods

4.1.1. Final exam

The final exam is still an important way to assess students' learning achievements, but the traditional exam format should be changed. The proportion of comprehensive and open-ended questions should be increased,

and attention should be paid to examining students' understanding and application ability of knowledge. At the same time, the proportion of final exam scores in the total evaluation scores should be appropriately reduced to avoid students relying too much on the final exam ^[10].

4.1.2. Usual grades

Usual grades should include multiple aspects such as classroom performance, homework completion, experiment reports, and course designs. Teachers should give evaluations and feedback in time according to students' performance and urge students to actively participate in the learning process. The proportion of usual grades in the total evaluation scores should be appropriately increased to encourage students to pay attention to usual learning ^[11].

4.1.3. Practical assessment

Practical assessment is an important way to assess students' practical ability. Practical assessment should include links such as experiments, course designs, and internships. Teachers should give evaluations and feedback according to students' performance in practical skills, such as experimental operation ability, data analysis ability, and rationality of design schemes. The proportion of practical assessment scores in the total evaluation scores should be appropriately increased to highlight the importance of practical ability ^[12,13].

4.1.4. Group project assessment

Group project assessment is an important way to cultivate students' teamwork and innovation abilities. Teachers should assign group project tasks according to the course content and let students complete them in groups. Teachers should give evaluations and feedback according to the completion situation of group projects, such as the innovation, feasibility, and teamwork ability of the projects. The proportion of group project assessment scores in the total evaluation scores should be appropriately increased to encourage students to actively participate in group projects.

4.2. Emphasizing process assessment

4.2.1. Classroom performance assessment

Teachers should pay attention to students' classroom performance, such as attendance, classroom participation, and asking and answering questions. Teachers can assess students' classroom performance through roll call, asking questions, and group discussions, and give evaluations and feedback in time ^[14].

4.2.2. Homework assessment

Teachers should assign an appropriate amount of homework for students to complete after class. The content of homework should cover the key points and difficulties of the course, and the forms can be diversified, such as calculation questions, short answer questions, and papers. Teachers should carefully correct students' homework, give evaluations and feedback in time, and include homework scores in the total evaluation scores.

4.2.3. Experiment report assessment

Experiment reports are an important basis for assessing students' experimental ability. Teachers should require students to write experiment reports carefully. The content should include the purpose of the experiment, the principle of the experiment, the experimental steps, and the results and analysis. Teachers should carefully correct students' experiment reports, give evaluations and feedback in time, and include experiment report

scores in the total evaluation scores.

4.2.4. Course design assessment

Course design is an important way to assess students' comprehensive application ability. Teachers should assign some course design tasks according to the course content and let students complete them within a specified time. Teachers should carefully guide students' course design, give evaluations and feedback in time, and include course design scores in the total evaluation scores.

4.3. Strengthening the assessment of practical ability

4.3.1. Experiment assessment

Experiment assessment should include aspects such as experimental operation ability, experimental data processing ability, and experiment report writing ability. Teachers should give evaluations and feedback according to students' performance in experiments, and include experiment assessment scores in the total evaluation scores.

4.3.2. Course design assessment

Course design assessment should include aspects such as the rationality of the design scheme, the accuracy of design calculations, and the standardization of design drawings. Teachers should carefully guide students' course design, give evaluations and feedback in time, and include course design assessment scores in the total evaluation scores.

4.3.3. Internship assessment

Internship assessment should include aspects such as internship performance and internship report writing ability. Teachers should cooperate closely with internship units to jointly assess students' internships and include internship assessment scores in the total evaluation scores.

4.4. Establishing a scientific evaluation system

4.4.1. Establishment of evaluation index system

Establishing a scientific evaluation index system is the key to the reform of assessment methods. The evaluation index system should include multiple aspects such as the degree of mastery of professional knowledge, practical ability, innovation ability, teamwork ability, and communication ability. Specific evaluation indicators should be set for each aspect so that teachers can conduct comprehensive and accurate evaluations of students^[15].

4.4.2. Selection of evaluation methods

Evaluation methods should be diversified, including a combination of quantitative evaluation and qualitative evaluation, a combination of teacher evaluation and student mutual evaluation, and a combination of process evaluation and summative evaluation. Through the comprehensive application of multiple evaluation methods, the objectivity and accuracy of evaluation results can be improved.

4.4.3. Feedback and application of evaluation results

Evaluation results should be timely fed back to students so that they can understand their learning situation and existing problems. Teachers should adjust teaching methods and progress in time according to evaluation results and provide targeted guidance and help to students. At the same time, evaluation results should also be used as

an important basis for students' evaluation and selection, scholarship evaluation, and graduation qualification review.

5. Evaluation of assessment methods

5.1. Comparison of assessment methods after reform

Compared with traditional assessment methods, there are obvious changes in assessment methods. The proportion of usual grades and practical ability assessment scores has increased significantly, as shown in **Table 1**.

Table 1. Comparison of traditional assessment methods and reformed assessment methods

Assessment method	Traditional assessment	Reformed assessment
Proportion of usual grades	20%	40%
Exam form	Closed-book exam mainly	Combination of multiple forms

5.2. Satisfaction survey of different assessment methods

After the implementation of the new assessment method, students' satisfaction has increased significantly, and the number of dissatisfied students has decreased significantly, as shown in **Table 2**.

Table 2. Satisfaction survey of students on different assessment methods (unit: %)

Assessment method	Very satisfied	Satisfied	General	Dissatisfied
Traditional assessment method	15.34	30.47	32.06	22.13
Reformed assessment method	36.58	46.49	14.11	2.82

5.3. Student grade distribution

By comparing and analyzing students' grade distribution, practical ability performance, and employment situation before and after the implementation of the assessment method reform, specific data is used to support the effectiveness of the assessment method reform. For example, before the reform, the average score of students' final exams was about 70 points, and the grade distribution was relatively concentrated; after the reform, the average score of students' final exams increased to about 75 points, and the grade distribution was more reasonable. The proportion of students in high-score and low-score segments has decreased. At the same time, students' performance in practical ability has also been significantly improved. The proportion of students participating in practical projects has increased from 40% before the reform to 60%, and students' employment competitiveness has also been enhanced.

6. Conclusion

The reform of assessment methods for core courses of the traffic engineering specialty is a systematic project that requires the joint efforts of schools, teachers, and students. By introducing diversified assessment methods, focusing on process assessment, and strengthening the assessment of practical abilities, students' learning enthusiasm and initiative can be improved, and students' innovation ability and practical ability can be cultivated to meet the needs of traffic engineering professionals in the new era. In the process of reform, experience should be continuously summarized, assessment methods should be improved, and a scientific

evaluation system should be established to provide a strong guarantee for improving the teaching quality of the traffic engineering specialty.

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Research on the Deepening of Mass Entrepreneurship and Innovation Education in Higher Vocational Colleges and the Practical Path of Industry-Education Integration in the New Era

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Abstract: The integration of industry and education provides intrinsic support for the construction of a collaborative education system between higher vocational colleges and enterprises. Based on the integration of industry and education, higher vocational colleges develop mass entrepreneurship and innovation education, which also requires the establishment of systems and institutions for mass entrepreneurship and innovation education to internally support the steady progress of the integration of industry and education. By clarifying the new demands for mass entrepreneurship and innovation education and the integration of industry and education in the new era, while further strengthening balanced development layouts, identifying practical educational issues in mass entrepreneurship and innovation education and the integration of industry and education, and formulating scientific practical strategies, this study expands the new development path of deepening mass entrepreneurship and innovation education and the integration of industry and education in higher vocational colleges, providing educational support for the coordinated advancement of mass entrepreneurship and innovation education and the integration of industry and education in higher vocational colleges.

Keywords: Higher vocational colleges; Mass entrepreneurship and innovation education; Integration of industry and education; Practical path

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1. Introduction

Currently, the steady advancement of mass entrepreneurship and innovation education for professional talents provides multifaceted educational support for the development of the integration of industry and education in

higher vocational colleges. Building on the educational layout of integration of industry and education based on the system construction of mass entrepreneurship and innovation education, it is essential to scientifically address educational alignment and design in accordance with the current needs for cultivating talents in mass entrepreneurship and innovation, and the educational planning for the integration of industry and education. This ensures the continuous strengthening of coordinated advancement of mass entrepreneurship and innovation education and the integration of industry and education, facilitating the transformation of talent development outcomes in higher vocational colleges. This foundation solidifies the high-quality progression of mass entrepreneurship and innovation education and the integration of industry and education in higher vocational colleges.

2. Requirements and background of deepening mass entrepreneurship and innovation education integration of industry and education in higher vocational colleges in the new era

In July 2019, the Ministry of Education of the People's Republic of China printed and distributed a notice on the *Management Measures for the National Undergraduate Innovation and Entrepreneurship Training Program*, clearly stating, "Key support is provided for training and practical projects directly targeting college students that are novel in content, clearly defined in objectives, demonstrate a certain level of creativity and exploratory nature, and have innovative technology or business models. The National Innovation Program adopts a project-based management approach, categorized into three types^[1,2]: innovation training projects, entrepreneurship training projects, and entrepreneurship practice projects." Enhancing the practical training capabilities of college students in mass entrepreneurship and innovation education and providing support for students by offering position-specific practical training, entrepreneurship practical training, and development training based on commercial development will be key factors in advancing the construction of the mass entrepreneurship and innovation education system^[3]. In this regard, efforts should focus on exploring educational practical training resources for college students, including establishing a practical training support system, enhancing practical training service capabilities, and improving the specificity of practical training, to support the development of college students in mass entrepreneurship and innovation. After years of construction and development, China's mass entrepreneurship and innovation education for university students has begun to show initial results. By constructing a diverse integrated education system with mass entrepreneurship and innovation education as the mainstay, significant support has been provided for the cultivation of mass entrepreneurship and innovation talents. To better maintain the positive momentum of education in mass entrepreneurship and innovation and achieve steady and incremental progress in mass entrepreneurship and innovation education, in December 2023, the Ministry of Education of the People's Republic of China issued a *Notice Regarding the 2024 National General Higher Education Graduates Employment and Entrepreneurship Work*. The notice actively encourages and supports university graduates to start their businesses independently, implementing entrepreneurship support policies, and providing tender support to graduate entrepreneurs in terms of funding, premises, and other aspects, to provide services for university graduates in innovation, entrepreneurship incubation, and outcome transformation. Based on the requirements of the Ministry of Education of the People's Republic of China for the employment and entrepreneurship of general higher education graduates, higher vocational colleges should adhere to practical exploration of new thoughts, utilize new carriers such as the creative economy, digital economy, and platform economy, and continuously improve the system for education mass entrepreneurship and innovation talents, laying a solid foundation for talents from vocational colleges to better integrate into

the development environment of mass entrepreneurship and innovation in the new era. Integration of industry and education, as a scientific measure to deepen cooperation between universities and enterprises in education, further aligns with the new requirements for cultivating mass entrepreneurship and innovation talents in the new era ^[4]. Relying on enterprise development platforms, industry innovation platforms, and technology research and development platforms, enhancing the resource supply for mass entrepreneurship and innovation education, enriching the structure, content, and education system of mass entrepreneurship and innovation education, and establishing a multi-path collaborative educational model based on a multi-pronged educational approach will be key to improving the quality of mass entrepreneurship and innovation education in universities. Simultaneously, effectively utilizing practical training and educational guidance in mass entrepreneurship and innovation education to contribute to the development of integration of industry and education, enabling the utilization of resources from mass entrepreneurship and innovation education to strengthen educational cooperation with enterprises, is crucial. Consequently, the higher vocational colleges' mass entrepreneurship and innovation education and integration of industry and education can achieve a two-way complement. Therefore, the deepening of the integration of industry and education through mass entrepreneurship and innovation education in higher vocational colleges is essentially based on a system of balanced development. This fosters a close connection between the integration of industry and education and mass entrepreneurship and innovation education, enhancing mutual educational support between the two and altering the educational landscape where integration of industry and education and mass entrepreneurship and innovation education operate in isolation. This empowers mass entrepreneurship and innovation education to provide a stronger internal driving force for education and development under the integration of industry and education.

3. Internal support for the deepening of mass entrepreneurship and innovation education and the integration of industry and education in higher vocational colleges in the new era

3.1. Collaborative education platform

The collaborative education platform serves as a crucial internal support for the deepening of the integration of industry and education in mass entrepreneurship and innovation education. The advancement of mass entrepreneurship and innovation education in higher vocational colleges should rely on educational channels for the integration of industry and education to ensure educational alignment. By continuously strengthening educational permeation and practical training in mass entrepreneurship and innovation, enhancing students' accumulation of experiences in innovation and entrepreneurship, and expanding students' new perspectives on innovation and entrepreneurship development, higher vocational colleges can broaden their horizons. Relying on the support provided by enterprises for mass entrepreneurship and innovation education in higher vocational education continuously enhances students' comprehensive development capabilities in mass entrepreneurship and innovation and bridges inherent differences in cultivating mass entrepreneurship and innovation talents in the new era. This supplements the practical content of mass entrepreneurship and innovation education, establishes a dual-integrated online and offline channel for practical mass entrepreneurship and innovation, and enables higher vocational colleges to utilize integration of industry and education to effectively develop the mass entrepreneurship and innovation education system, embedding mass entrepreneurship and innovation education into various aspects of integration of industry and education ^[5]. Therefore, the construction of the collaborative education platform creates favorable conditions for the deepening development of integration of industry and education in mass entrepreneurship and innovation education in higher vocational colleges,

enabling complementary content and structural integration between mass entrepreneurship and innovation education and integration of industry and education, thereby solidifying the foundation for the long-term advancement of integration of industry and education and mass entrepreneurship and innovation education in higher vocational colleges.

3.2. Practical training systems in mass entrepreneurship and innovation education

Deepening the practice of integrating mass entrepreneurship and innovation education into industry and education requires focusing on the cultivation of mass entrepreneurship and innovation talents as the core of exploring education under the integration of industry and education. Applying the education model of integration of industry and education to the cultivation of mass entrepreneurship and innovation talents, and utilizing integration of industry and education in the practical aspects of mass entrepreneurship and innovation education for the transformation of educational outcomes are necessary. Therefore, higher vocational colleges should rely on the practical training system construction of the integration of industry and education to provide practical training support for mass entrepreneurship and innovation education. By enhancing the practical training capabilities and educational guidance of mass entrepreneurship and innovation education and strengthening the feedback of practical training in mass entrepreneurship and innovation education to address educational issues and demands under integration of industry and education, higher vocational colleges can judiciously adjust the educational structure and planning of integration of industry and education and provide diverse information references for the educational design of integration of industry and education across various disciplines ^[6]. This allows higher vocational colleges to better advance the practical training of integration of industry and education based on mass entrepreneurship and innovation education. Therefore, the construction of the system for practical training in mass entrepreneurship and innovation education is essentially providing educational support for enhancing the education mechanism under integration of industry and education, enabling higher vocational colleges to continuously optimize educational thoughts of integration of industry and education while enhancing the quality of mass entrepreneurship and innovation education, laying a solid foundation for the future advancement of integration of industry and education within higher vocational colleges.

4. Dilemmas of higher vocational colleges in deepening the integration of industry and education by relying on mass entrepreneurship and innovation education

4.1. Lack of a close connection between mass entrepreneurship and innovation education in higher vocational colleges and the integration of industry and education

Ensuring the close connection between mass entrepreneurship and innovation education and the integration of industry and education involves applying the concepts, educational content, and resources of mass entrepreneurship and innovation education to the educational practices of integration of industry and education. This further enhances the top-level design of the integration of industry and education, serving as a focal point for deepening the integration of mass entrepreneurship and innovation education into this framework. Some higher vocational colleges' collaborative system constructions for mass entrepreneurship and innovation education and integration of industry and education focus solely on educational layouts within singular fields, failing to adequately create space for the deepening integration of mass entrepreneurship and innovation education into integration of industry and education, thus preventing a close connection between the two. For instance, some higher vocational colleges' constructions of mass entrepreneurship and innovation education systems concentrate solely on reinforcing students' knowledge reserves in innovation and entrepreneurship

without properly addressing the practical training needs for mass entrepreneurship and innovation talents, hindering effective educational connections towards the integration of industry and education. This limitation makes it difficult for the integration of industry and education's educational practical training with enterprises to tailor educational designs specifically for mass entrepreneurship and innovation education, thereby impeding the collaborative advancement of mass entrepreneurship and innovation education and integration of industry and education ^[7]. From the perspective of education under the integration of industry and education, the reality of inadequate practical guidance abilities in mass entrepreneurship and innovation education leads to university students struggling to effectively link the content of mass entrepreneurship and innovation knowledge, disciplinary subjects, and positional practical training. This exacerbates the fragmented learning of mass entrepreneurship and innovation knowledge and practical skills among university students, rendering the deepening integration of mass entrepreneurship and innovation education into the integration of industry and education a mere rhetoric.

4.2. Unreasonable allocation of educational resources for mass entrepreneurship and innovation education and integration of industry and education in higher vocational colleges

In order to deepen the integration of mass entrepreneurship and innovation education into the integration of industry and education development, it should be based on the construction of a cross-fusion system, reasonably allocating educational resources to ensure that mass entrepreneurship and innovation education and the integration of industry and education complement and support each other. However, some higher vocational colleges have not fully leveraged the complementary advantages of resources for effective educational guidance. Instead, these higher vocational colleges have resorted to a crude and simplistic overlapping structure, directly applying the content of mass entrepreneurship and innovation education to the educational practices of integration of industry and education, thereby hindering students from effectively digesting and absorbing the content and knowledge of mass entrepreneurship and innovation education. The primary reason behind this issue lies in the failure of higher vocational colleges to conduct a comprehensive educational assessment of resource allocation, leading to a lack of understanding regarding the application needs of educational resources for mass entrepreneurship and innovation education and integration of industry and education, thereby keeping mass entrepreneurship and innovation education consistently outside the education system of integration of industry and education ^[8]. Integration of industry and education also struggles to provide diversified practical training support for mass entrepreneurship and innovation education. Additionally, some higher vocational colleges overly emphasize phased educational outcomes in curriculum design, neglecting control over educational details and processes. This oversight results in a lack of educational direction and purpose in the utilization of educational resources for mass entrepreneurship and innovation education and integration of industry and education, which hampers the steady progress of higher vocational colleges' mass entrepreneurship and innovation education and integration of industry and education. Consequently, the advancement of mass entrepreneurship and innovation education in higher vocational colleges is destined to fall short in providing support for the integration of industry and education.

4.3. Insufficient educational leadership capacity in enterprises' mass entrepreneurship and innovation education and integration of industry and education

Currently, the system construction of mass entrepreneurship and innovation education in higher vocational colleges primarily focuses on enhancing students' vocational development capabilities, emphasizing the

improvement of teachers' educational abilities, and strengthening the cultivation of students' practical training abilities in a certain aspect of education design. In practice, however, insufficient attention has been given to the system construction of mass entrepreneurship and innovation education, leading to the inability of higher vocational colleges to achieve an educational cycle between mass entrepreneurship and innovation education and the integration of industry and education. The core influencing factors that lead to this issue in higher vocational colleges are twofold. Firstly, higher vocational colleges have not strengthened the educational leadership capacity of enterprises, causing a lack of understanding by enterprises regarding the educational goals and positioning of higher vocational colleges, thus making it difficult to utilize enterprise resources to provide targeted educational support for the integration of industry and education or mass entrepreneurship and innovation education. Secondly, higher vocational colleges have failed to effectively control the teaching pace of mass entrepreneurship and innovation education and the integration of industry and education, resulting in challenges in connecting the teaching and practical training of mass entrepreneurship and innovation education with current industry trends, entrepreneurship policies, and enterprise manpower needs in a systematic manner. Consequently, the collaborative education efforts between higher vocational colleges' mass entrepreneurship and innovation education and the integration of industry and education lose practical significance. Therefore, the insufficient educational leadership capacity of enterprises and the ineffective control of educational pace by higher vocational colleges diminish the quality of student education, restricting the deepening of mass entrepreneurship and innovation education within the integration of industry and education development solely to educational connections within the campus environment, impeding the effective cross-fusion of educational cultivation tailored towards enterprise practical training. Ultimately, this dilemma results in the collaborative student education efforts between higher vocational colleges' mass entrepreneurship and innovation education and the integration of industry and education facing significant challenges in educational development.

5. Practical paths for deepening the integration of industry and education based on mass entrepreneurship and innovation education in higher vocational colleges

5.1. Constructing a diversified collaborative practice system for mass entrepreneurship and innovation education and integration of industry and education

Constructing a diversified collaborative practice system for mass entrepreneurship and innovation education and integration of industry and education requires higher vocational colleges to perfect the educational content, programs, and practical modules during the formulation of mass entrepreneurship and innovation education planning. The higher vocational colleges should systematically lay out the practice of mass entrepreneurship and innovation education based on the innovative entrepreneurship development needs of students in different disciplines. This creates educational space for education under the integration of industry and education, enabling the integration of mass entrepreneurship and innovation education content with various disciplinary knowledge to ensure that students can strengthen the alignment of educational content between mass entrepreneurship and innovation education and the integration of industry and education. For instance, in the practical layout of mass entrepreneurship and innovation education, higher vocational colleges should adjust educational plans according to the diverse practical training projects in each professional field of integration of industry and education. The higher vocational colleges should seamlessly integrate mass entrepreneurship and innovation education practical content closely related to professional practical training into the current educational practice system and provide support for students' learning and practical application of mass entrepreneurship and innovation knowledge. When necessary, higher vocational colleges can incorporate

certain elements of mass entrepreneurship and innovation education into integration of industry and education, allowing students to understand enterprise operational models, development strategies, and various job responsibilities through practical training, thus helping students validate mass entrepreneurship and innovation course knowledge during the practical training within integration of industry and education. This approach enables mass entrepreneurship and innovation education to penetrate education, with a focus on the integration of industry and education. Integration of industry and education can also serve as an educational practical training platform for mass entrepreneurship and innovation education, enhancing the collaborative educational capabilities between higher vocational colleges' mass entrepreneurship and innovation education and integration of industry and education. This consolidates the foundation for the enhancement of the closer integration between mass entrepreneurship and innovation education in higher vocational colleges and industry-education integration.

5.2. Deepening the educational layout of integration of industry and education in higher vocational colleges' project practical training

Deepening the educational layout of integration of industry and education in project practical training at higher vocational colleges refers to optimizing the allocation scheme of educational resources for mass entrepreneurship and innovation education and integration of industry and education through vocational talents' practical training in enterprises. By addressing the bidirectional requirements of mass entrepreneurship and innovation education and the integration of industry and education through practical placements, effective balancing of educational resource allocation is achieved. This allows higher vocational colleges to adequately supply resources for mass entrepreneurship, innovation education, and integration of industry and education based on an assessment of educational needs. For example, higher vocational colleges can directly arrange rotational practical training for students through industry channels after completing phased learning tasks. This allows students to engage in rotational practical training in enterprises, participate in entrepreneurial projects or position practice projects, understand the needs of entrepreneurial initiatives and position innovations in companies, and enrich their experiences in innovative entrepreneurship development. Based on students' performance and the various learning and practical training issues observed during rotational practical training in enterprises, assessments are conducted for education under mass entrepreneurship and innovation education and integration of industry and education. This analysis identifies educational deficiencies in the collaborative education of mass entrepreneurship, innovation education, and the integration of industry and education in various aspects. Subsequently, based on the arrangement of follow-up educational tasks and the formulation of educational plans, different educational resource support is provided for mass entrepreneurship and innovation education and the integration of industry and education. This targeted application of educational resources effectively addresses education and training issues within mass entrepreneurship, innovation education, and the integration of industry and education. Vocational talents not only clarify their subsequent learning goals through project practical training but also provide teaching references in mass entrepreneurship and innovation education and integration of industry and education for teachers, helping them enhance the effective utilization of various teaching resources. This alignment ensures that higher vocational colleges' mass entrepreneurship and innovation education and integration of industry and education progress consistently. It enables mass entrepreneurship and innovation education to strategically position educational decisions according to the needs of integration of industry and education practical training and achieve coordinated education under mass entrepreneurship and innovation education and integration of industry and education.

5.3. Establishing an enterprise-led education model for mass entrepreneurship and innovation education and integration of industry and education

Establishing an enterprise-led education model for mass entrepreneurship and innovation education and integration of industry and education helps address the insufficient education leadership capabilities of enterprises in mass entrepreneurship and innovation education and integration of industry and education. Enterprise leadership refers to enterprises taking the lead in educational decision-making for the integration of industry and education, providing support in various aspects like teacher training, student practical training, and resource optimization for higher vocational colleges' mass entrepreneurship and innovation education. This involvement enables enterprises to participate in education and develop mass entrepreneurship and innovation education within higher vocational colleges. By guiding higher vocational colleges' mass entrepreneurship and innovation education development and educational decisions related to integration of industry and education, enterprises help empower higher vocational colleges to deepen mass entrepreneurship and innovation education within the framework of integration of industry and education, ultimately enhancing the quality of education in mass entrepreneurship and innovation education and integration of industry and education^[9]. For example, guided by enterprise-led mass entrepreneurship and innovation education service directives, providing teacher training support to higher vocational colleges can enhance teachers' understanding of current industry development trends, innovative entrepreneurship policies, and regional innovation and entrepreneurship requirements. This dynamic approach enables teachers to design education programs according to the specific needs of innovation and entrepreneurship development in different regions. Furthermore, enterprises can engage in the construction of educational platforms for education, allowing project leaders of relevant entrepreneurial initiatives or industry experts to participate in interactive practices within mass entrepreneurship and innovation education. Through relying on educational channels within the integration of industry and education, enterprises can support mass entrepreneurship and innovation education, focusing on enhancing the quality of practical experiences. This approach helps higher vocational colleges effectively integrate practical training within the integration of industry and education by utilizing mass entrepreneurship and innovation education, thereby applying subject-specific and foundational knowledge from the integration of industry and education to practical applications within mass entrepreneurship and innovation education. This multivariate cycle achieves a synergy between mass entrepreneurship and innovation education and integration of industry and education, elevating the quality of education provided by higher vocational colleges in mass entrepreneurship and innovation education and integration of industry and education. Additionally, establishing an enterprise-led education model for mass entrepreneurship and innovation education and integration of industry and education enables better management of educational pacing in higher vocational colleges. This strategic alignment ensures that higher vocational colleges can deliberately advance mass entrepreneurship and innovation education in line with enterprise entrepreneurial models and workforce demands, providing targeted support for the integration of industry and education to foster collaboration in education across various domains with enterprises.

6. Conclusion

In summary, in the new era, the deepening of the integration of industry and education within mass entrepreneurship and innovation education at higher vocational colleges will prioritize the cultivation of talent in mass entrepreneurship and innovation. This will involve enhancing the practical training capabilities in mass entrepreneurship and innovation education, fostering a closer connection between mass entrepreneurship and innovation education and integration of industry and education at higher vocational colleges. This

connection aims to enable mass entrepreneurship and innovation education to address the new demands in talent development of the current era more effectively, thereby better supporting the integration of industry and education. This will facilitate bi-directional coordination in the development of mass entrepreneurship and innovation education and the integration of industry and education at higher vocational colleges, enhancing the timeliness and specificity of education talent in mass entrepreneurship and innovation in the new era. These efforts will establish a solid foundation for higher vocational colleges to maintain a balanced development of mass entrepreneurship, innovation education, and integration of industry and education.

Disclosure statement

The author declares no conflict of interest.

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Domestic and International Research on Science and Technology Education: Review and Prospects

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Abstract: Competition in science and technology is the core of the national game in the new era. The construction of science and technology education, as an important force to promote national strategic scientific and technological power, is highly valued by all countries. Three developed countries in science and technology, the United States, Japan, and the United Kingdom, are the main research objects for analyzing their science and technology education. Domestic research on science and technology education mainly focuses on the theoretical and practical research of science and technology education activities. In the future, it is necessary to learn from the experience of foreign countries in the development of science and technology education, explore the localization of science and technology education activities, strengthen the top-level design of science and technology education, and highlight the strategic transformation of the trinity of “education, science and technology, and talents.”

Keywords: Science and technology education; Review; Reflection and prospects

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1. Introduction

The Chinese President pointed out that: “building a strong education, science and technology, and talent is inherently consistent and mutually supportive, and we should organically combine the three, promote them as a whole, and form a multiplier effect to promote high-quality development. We need to smooth the virtuous circle of education, science and technology, and talent in accordance with the requirements of developing new quality productivity.” In view of this, in-depth study of science and technology education is not only a key path to promote the strategic layout of “education, science and technology, talent” trinity, but also a core engine to drive the development of new quality productivity. Therefore, using the China National Knowledge Infrastructure (CNKI) database, we searched the literature of “science and technology education,” and analyzed and summarized the domestic literature on science and technology education after reading the literature. In addition, the English literature is mainly collected through “Baidu Academic,” “Sci-Hub,” and other channels

with the keyword “technology education” to understand the current situation of foreign research on technology education. It is of great practical significance to analyze and reflect on the domestic and foreign research on science and technology education, and to look forward to the future direction of research on science and technology education, in order to promote the implementation of science and technology education.

2. Review and reflection on domestic and international research on science and technology education

2.1. Research on science and technology education abroad

Science and technology education is an important part of basic education in many countries. Developed countries attach particular importance to the development of science and technology education both in and out of school. In recent years, developed countries such as the United States, Japan, and the United Kingdom have increased their investment in science and technology education, vigorously developing science and technology education for young people, and have gradually formed their own styles of science and technology education models for young people.

2.1.1. Research on science and technology education in the United States

In October 1957, as the U.S.-Soviet rivalry became more and more intense, some U.S. educators believed that the Soviet Union’s leadership was mainly due to the success of science education, and therefore believed that U.S. basic education had to be reformed and the construction and change of “science and technology education” had to be strengthened. Therefore, in 1983, the U.S. Federal Department of Education published the *Report of the National Commission on Gifted Education: A Nation in Crisis*, which suggested that science classes must be modified and modernized to benefit those who were not prepared to enter college and those who were prepared to take college entrance exams. In 1985, the United States began a program of science and technology education with the main goal of improving the scientific and technological literacy of all Americans, and put forward the slogan of “science for all Americans” in the education sector, and formulated the famous “2061 program”^[1]. In the 80s of the 20th century, the United States proposed Science, Technology, Engineering, and Math, referred to as STEM, to train mathematicians, scientists, engineers, and technicians with scientific literacy^[2]. Over the past 40 years, the U.S. government and a number of scientific research institutions, colleges and universities, and foundations have promoted the deepening of STEM education through a variety of ways.

2.1.2. Research on science and technology education in Japan

The structure of the Japanese elementary and secondary school curriculum includes “Science and Technology Study Time” in addition to “Compulsory Subjects”^[3]. The Japan Science and Technology Agency (JST), a national research and development corporation, has been creating Science Koshien since the 23rd year of the Heisei era, and is aiming to create a place where high school students can gather for hands-on science activities, and by creating such a place, it is aiming to expand the students’ enjoyment of science and to improve their high-level abilities^[4].

In addition, the Government of Japan has formulated science and technology policies to support the implementation of science and technology education. In the 7th year of the Heisei era, the Japanese government implemented a systematic and consistent science and technology policy from a long-term perspective, and formulated the Basic Law for Science and Technology, or the “Science and Technology Basic Plan,” which has been formulated in five phases so far, has promoted the implementation and development of science and

technology policies. Afterwards, the Basic Law for Science and Technology was amended to “Basic Law for Science, Technology and Innovation” due to the amendment of the law in June of the second year of the Order, and the Basic Plan for the Third Year of the Order was formulated^[5]. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) has been promoting “science for policy” in science, technology, and innovation policy since the 23rd year of the Heisei era, with the goal of realizing “policy formation based on objective evidence.” With the cooperation of related organizations and bases for basic research and human resources development, a Promotion Program (SciREX Program) was established^[6].

2.1.3. Research on science and technology education in the United Kingdom

Science and technology (S&T) education is an important part of the innovation ecosystem in the U.K. In 2004, the U.K. government formally promulgated for the first time a medium- and long-term S&T development plan: the Science and Innovation Investment Framework (2004–2014), which aims to promote the development of innovation in S&T education and strengthen the mutual synergy between higher education institutions and enterprises^[7]. The Royal Society (RS), the Royal Society of Chemistry (RSC), the Institute of Physics (IOP), the British Standards Institution (BSI), etc., are generally the venues for students to carry out S&T education. Research funding for students in the UK to undertake science and technology education mainly comes from the government, corporations, universities, and private funding.

To summarize, the development of science and technology education in the West has been made possible by the support of the government, schools, and communities. The government provides policy guarantees for the implementation of science and technology education activities, and schools and communities provide support in terms of personnel and venues for the development of science and technology education activities. At the same time, museums, libraries, university research institutes, and even personal studios of scientists in many Western countries are open to students. Students are less burdened with schoolwork, so they have plenty of time after school to participate in science and technology activities of their own interest.

2.2. Domestic research on science and technology education

2.2.1. Theoretical research focusing on STE activities

Qi has studied the theory of science and technology education in primary and secondary schools, i.e., he has made a more comprehensive overview of the six aspects of science and technology education, namely, the proposal, meaning, goal, content, implementation, and methods^[8]. Wang has sorted out the results of research and exploration of science and technology education in China from four aspects, namely, the meaning, objectives and contents of science and technology education, the principles, ways and methods of implementing science and technology education, and the practice mode of science and technology education, so as to provide theoretical references for the study of science and technology education. Wang’s research ideas have commonalities with Qi’s in terms of meanings, objectives, ways, and methods. The differences lie in the principles of implementing science and technology education and the mode of practical exploration. Among them, Wang summarized some models with certain characteristics and representativeness: “science practice class,” “integrated science,” “science and technology high school,” and “resource gifted class.” Qi summarized “Resource Gifted Classes,” “Junior Science Academy,” “Creative Science and Technology Education,” “Industrial Science and Technology Education,” “S.T.S (Science, Technology and Society),” “Multi-channel Progress,” “Science Clubs,” and “Curriculum Advancement and Breakthrough.” The action models in the ten major areas provide reference for frontline schools to carry out science and technology education^[9].

It can be seen that in the research of science and technology education theory, scholars have given full theoretical guidance to “how teachers should teach” and “how students should learn” science and technology education. After the emergence of STEM education (Science, Technology, Engineering, and Mathematics) in foreign countries, scholars have introduced and thought about the theory of STEM education, combined with the development of science education in their own countries, and carried out localized research on STEM education, which has greatly enriched the theoretical system of scientific and technological education activities in China.

2.2.2. Practical exploration of science and technology education activities based on core literacy

Some scholars take Beijing Jingshan School as the experimental position, actively seek the talent cultivation path compatible with the current primary and secondary education, and solidly push forward the reform of science and technology education from the perspective of core literacy, and gradually form a long-chain characteristic science and technology education model linking primary, junior, and senior high schools^[10]. Under the perspective of core literacy, some scholars analyze the basic concepts of youth science and technology innovation education, explore the problems of youth science and technology innovation localization practice, and put forward specific practical measures: guiding students to carry out extracurricular science and technology practice activities based on classroom teaching content, and carrying out diversified extracurricular science and technology practice activities in the second classroom to cultivate students’ scientific innovation ability and quality^[11].

3. Prospects of science and technology education research

3.1. Exploring the construction of localization of science and technology education activities by drawing on overseas experience in the development of science and technology education

The key to the localization of science and technology education activities lies in the organic unity of systematic reference to foreign experience in science and technology education and in-depth integration of regional cultural resources. In order to achieve this goal, educators need to build a science and technology education system with an international vision and local characteristics, with the fundamental orientation of “what kind of people to cultivate, how to cultivate people, and for whom to cultivate people.” Firstly, teachers need to systematically study the curriculum design and evaluation system of science and technology education in foreign countries; secondly, on this basis, they should dig deep into the traditional cultural elements in school-based resources, and transform the scientific wisdom contained in local non-heritage skills and traditional crafts into educational materials. For example, we can creatively combine the mechanics of traditional construction techniques and the astronomical knowledge of the festival culture with the theme of modern science and technology education, and design special programs such as “mortise and tenon structure creation workshop” and “intelligent festival observatory.” Finally, through the logical theory of “introduction-deconstruction-reconstruction,” the experience of foreign science and technology education is deeply integrated with the local culture, and a localized curriculum system is explored, so that a science and technology education paradigm with the cultural genes of our country can be formed, and support is provided for the cultivation of talents with global competitiveness and cultural roots in the new era.

3.2. Strengthening the top-level design of science and technology education and emphasizing the strategic transformation of the trinity of “education, science and technology, and talents”

To strengthen the top-level design of science and technology education, it is necessary to take the trinity

development of “education, science and technology, and talents” as the strategic fulcrum, and build a systematic and sustainable strategic implementation system. Therefore, the school should be based on the national strategic needs—the education system innovation, scientific and technological resources integration, talent mechanism innovation—a strategic combination of the three, to build education, science and technology, talent synergistic development mechanism, systematic planning from the target positioning to the implementation of the path of the full cycle of design. First, the school development orientation should be deeply integrated with the goal of cultivating scientific and technological innovation talents; second, the school should break through the disciplinary barriers, design interdisciplinary integration of scientific and technological education curriculum clusters, and develop project-based learning resources reflecting the concepts of STEM education; third, the school should build a scientific and technological innovation literacy development-oriented evaluation system, and use this as a basis for the establishment of dynamic optimization of the cultivation of talents. Based on this, it is not only conducive to enhancing the effectiveness of science and technology education, but also continuously promote the emergence of high-level science and technology innovation talents, and ultimately realize the benign cycle of education empowering scientific and technological innovation, scientific and technological feedback on the growth of talents, and talents supporting the upgrading of education.

4. Conclusion

At present, China is in the process of moving from a “scientific and technological power” to a stronger “scientific and technological power.” There is a serious shortage of top-notch innovative talents in China, which has slowed down the progress of some high-end scientific research projects and bottlenecks in key core technologies, and severely limited the in-depth layout and rapid development of China’s strategic emerging industries, such as artificial intelligence and chip manufacturing. Therefore, it is of practical significance to study the domestic and foreign science and technology education for our country to cope with the science and technology competition strategy of the developed countries led by the United States against China in the new period.

Disclosure statement

The authors declare no conflict of interest.

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Construction of T-Structured Courses in Universities to Cultivate Future Researchers

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Abstract: University courses should have both breadth and depth. However, most courses in universities only focus on the breadth construction, while neglecting the depth construction, resulting in students being unable to apply the knowledge they have learned to conduct research or solve real-world application problems. The students' high-level abilities are insufficient and not well-trained. Therefore, in this paper, we propose a T-structured course design method to ensure both breadth and depth of a course. The proposed T-structured course design method includes four aspects: T-structured course contents, T-structured teaching activities, T-structured examination formats, and T-structured homework difficulty. By applying our proposed T-structured course design strategy to the course Optimization Algorithms and Intelligent Computing, good results are achieved, demonstrating the applicability of our proposed strategy.

Keywords: T-structured course; Course design; Teaching activity; Breadth; Depth

Online publication: June 4, 2025

1. Introduction

In university education, for students to deeply understand the contents of the course and proficiently master the methods introduced in the course, it is necessary to have both “breadth” and “depth” when teachers are designing the course.

“Breadth” refers to the requirement that the content introduced in a course must be comprehensive^[1,2], so that students can have a comprehensive and complete understanding of the discipline field the course covers. After knowing the whole picture, students are able to determine the appropriate solutions to solve the encountered problems in their work and study in the future. Without “breadth,” although students can proficiently use one or two techniques to solve problems, they will not be able to understand the differences and connections between methods, and will be in a state of partial understanding. Therefore, the breadth of teaching content determines students' perspectives.

“Depth” means that the contents of a course should be learned in a deep way^[1]. After studying a course deeply, students should become proficient in a certain technique within the course, in order to achieve the

effect of being able to apply it to solve practical problems skillfully. The depth of a course is one of the major factors influencing the ability of a student to tackle practical problems, i.e., the depth of a course determines its practicality. Only the techniques and methods that students can proficiently apply can be considered truly learned knowledge.

Without “breadth,” students will face the embarrassing situation of “seeing only the trees but not the forest.” In addition, without “depth,” students can only stay at the level of preliminary understanding. Students only know a little bit but are not proficient with the knowledge taught in the course, which will make students’ learning superficial and useless, resulting in the inability to apply the knowledge in their future work and research.

However, at present, many courses in universities only have a good design for breadth, while the design of depth is relatively weak. This results in students having learned a lot of knowledge, but their application ability is relatively weak. Due to the lack of in-depth learning, students’ learning of knowledge and technology only stays at a superficial level. Students’ advanced abilities cannot be cultivated ^[3], and their advanced abilities are actually the most important abilities required for their future scientific research and innovation.

“Breadth” is like a horizontal line of the letter T, and “depth” is like a vertical line of the letter T, as shown in Figure 1. A truly good course, a course that can benefit students, should be a combination of “breadth” and “depth,” i.e., a course with a “T-shaped” structure. Therefore, in this paper, we propose a strategy for building a T-structured course.

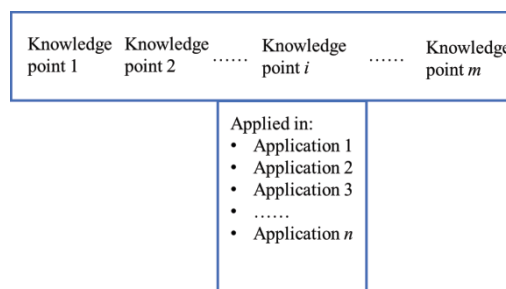


Figure 1. A T-structured course should have both breadth and depth

2. Proposed strategy

Following the idea of designing a T-structured course to consider both breadth and depth of a course, we propose to develop the following T-structured strategies: T-structured contents of a course, T-structured teaching activities, T-structured examination, and T-structured homework difficulty. We take the course Optimization Algorithms and Intelligent Computing as an example.

2.1. T-structured contents

The course Optimization Algorithms and Intelligent Computing mainly introduces four major categories of methods for solving optimization problems. They include the graphical methods, the heuristic methods, the analytical methods, and the numerical methods. Each category of the methods contains many different algorithms, so the content involved is quite extensive. The course has a wide breadth, as shown in **Figure 2**.

Furthermore, except for the breadth of the course, the depth of the course is also considered. Teachers should select one or two specific algorithms to discuss in detail and show different applications of these algorithms. For example, in the Optimization Algorithms and Intelligent Computing course, we select the

widely used algorithm, the genetic algorithm, as the method for “in-depth” teaching. We show students almost all the possible applications of the genetic algorithm. For instance, how genetic algorithm handles the linear programming problems, the integer programming problems, the combinatorial optimization problems, the problems with hard and soft constraints, continuous function optimization problems, artificial intelligence problems, feature selection problems in machine learning, hyperparameter optimization problems in machine learning models, network optimization problems, etc., as shown in **Figure 2**. This in-depth teaching can help students acquire a deep and thorough understanding of the genetic algorithm and help students apply this algorithm in future research.

Teachers can choose any other algorithm for the depth construction. We believe that choosing one or two algorithms for the depth construction is appropriate. Otherwise, there will be too much teaching content for the depth construction, which will affect the breadth construction.

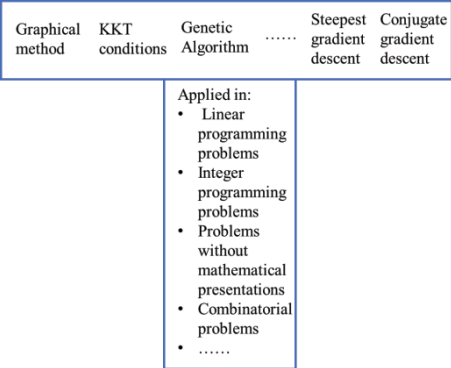


Figure 2. T-structured contents have both breadth and depth

2.2. T-structured teaching activities

Teaching activities need to be constructed in a T-structured format. The teaching of various knowledge points is conducted in the classroom as a means of breadth construction. The deep learning of a certain knowledge point is conducted outside the classroom as a means of depth construction. Students are asked to practice various application scenarios of a certain knowledge point during their time outside class. To monitor the students’ in-depth learning, students are required to submit their understandings of the content they have learned on a weekly basis and teachers should give students feedbacks and instructions about their deep learning outside class, as shown in **Figure 3**.

2.3. T-structured examinations

We design the examination as T-structured, as shown in **Figure 4**. As the exams belong to the breadth construction, a closed book exam format is used for each knowledge point. As the exams belong to the depth construction, we adopt the form of course projects and open book exams, such as requiring students to apply a certain algorithm to solve a practical problem, or giving students cutting-edge problems and topics for research.

2.4. T-structured homework difficulty

Students’ homework should include challenging problems, and homework problems with an elevating nature can promote students’ thinking and application abilities ^[4]. Therefore, the design of homework difficulty should also be T-structured, but is an inverted T, as shown in **Figure 5**.

For breadth construction, the difficulty level of homework is set to be the moderate level. For depth

construction, challenging problems of high level are adopted. Students are encouraged to do brain storming and discuss their solutions with their classmate in order to solve those challenging problems, since problem-based discussion is an effective way to help solve the problem ^[5].

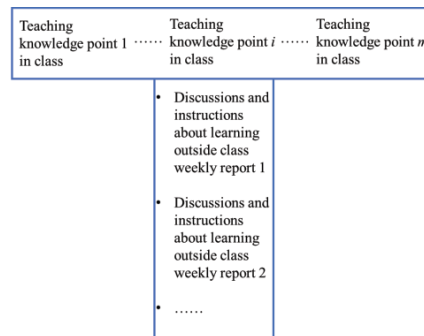


Figure 3. T-structured teaching activities have both breadth and depth

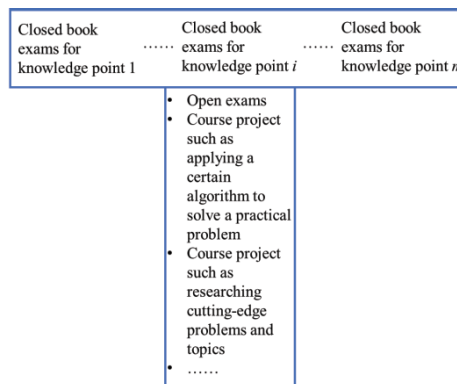


Figure 4. T-structured examinations have both breadth and depth

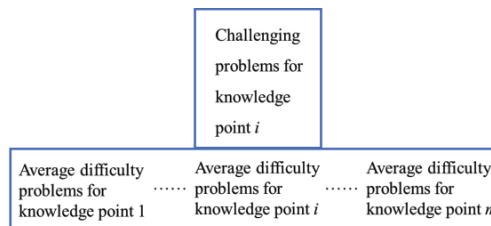


Figure 5. T-structured homework difficulty has both breadth and depth

3. Strategy implementation, results, and conclusions

We apply the proposed T-structured strategy on the course Optimization Algorithms and Intelligent Computing with a teaching class of 45 students. After one semester of implementation, 5 papers ^[6-10] have been published, including 4 conference papers and 1 SCI journal paper. The first authors are all undergraduate students. This result indicates that the proposed T-structured strategy is feasible and effective.

In conclusion, this paper proposes a T-structured course design strategy to improve the “breadth” and “depth” of university courses from four aspects: T-structured course contents, T-structured teaching activities, T-structured examination formats, and T-structured homework difficulty. While ensuring the “breadth” of the course, efforts are made to enhance the “depth” of the course, helping students have a broad understanding of the course content and high practical hands-on ability, thus improving the classroom teaching effectiveness of undergraduate courses.

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Research on the Construction and Practice of an Evidence-Based Value-Added Evaluation System Based on Data-Driven

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Abstract: Based on the educational evaluation reform, this study explores the construction of an evidence-based value-added evaluation system based on data-driven, aiming to solve the limitations of traditional evaluation methods. The research adopts the method of combining theoretical analysis and practical application, and designs the evidence-based value-added evaluation framework, which includes the core elements of a multi-source heterogeneous data acquisition and processing system, a value-added evaluation agent based on a large model, and an evaluation implementation and application mechanism. Through empirical research verification, the evaluation system has remarkable effects in improving learning participation, promoting ability development, and supporting teaching decision-making, and provides a theoretical reference and practical path for educational evaluation reform in the new era. The research shows that the evidence-based value-added evaluation system based on data-driven can reflect students' actual progress more fairly and objectively by accurately measuring the difference in starting point and development range of students, and provide strong support for the realization of high-quality education development.

Keywords: Data-driven; Evidence-based evaluation; Value-added evaluation; Large model; Educational evaluation reform

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1. Introduction

1.1. Research background and significance

As the “baton” of the education system, educational evaluation plays an important guiding role in the reform and development of education ^[1]. With the deepening of the digital transformation of education, the traditional results-oriented and single-dimensional evaluation method has been unable to meet the needs of education development in the new era. In 2020, the *Overall Plan for Deepening the Reform of Education Evaluation in*

the New Era issued by the CPC Central Committee and The State Council clearly points out that it is necessary to “establish a scientific evaluation system oriented by developing quality education,” which points out the direction for the reform of education evaluation ^[2]. In this context, an evidence-based value-added evaluation system based on data-driven came into being. The evaluation system reflects the “people-oriented” education concept by accurately measuring the starting point difference and development range of students, focusing on the progress and growth of each student, rather than simply comparing the final score. At the same time, emerging technologies such as big data and artificial intelligence provide technical support for accurate, scientific, and efficient educational evaluation, making all-round, multi-dimensional, and process-based evaluation possible ^[3].

1.2. Research objectives and core issues

This study aims to build a data-driven, evidence-based value-added evaluation system and verify its effectiveness through practical application. The specific research objectives include: designing a multi-source heterogeneous data acquisition and processing system, developing a value-added evaluation agent based on a large model, constructing a scientific and feasible evaluation implementation path, and forming an education evaluation reform plan that can be promoted. The research focuses on solving the following core problems: (1) How to build a multi-source heterogeneous data acquisition and processing system to achieve effective transformation from data to evidence? (2) How to build value-added evaluation agents based on large model technology to improve the accuracy and intelligence of evaluation? (3) How to design the implementation path of an evidence-based value-added evaluation system to ensure the effective application of evaluation results?

2. Literature review

2.1. Research progress of value-added evaluation theory

Value-added evaluation originated in the 1990s and was initially used to measure the contribution of teachers and schools to students’ academic progress ^[4]. The Tennessee Value-added Evaluation System (TVAAS), developed by Sanders, is an early representative value-added evaluation model ^[5]. In recent years, the theory of value-added assessment has undergone a transformation from a single-subject knowledge measurement to a multidimensional ability assessment, from a simple linear regression model to a complex multi-level model, and from a focus on teacher performance to a focus on the overall development of students ^[6]. Evidence-based evaluation originates from the idea of evidence-based education and emphasizes that evaluation decisions should be based on scientific evidence. Slavin pointed out that evidence-based education requires the use of “the best available evidence” to guide educational practice ^[7]. The reliability and validity of data and the science of interpretation are central elements in evidence-based evaluation.

2.2. Research on data application in educational evaluation

With the advent of the era of big data, the field of educational evaluation has changed from “data scarcity” to “data enrichment.” The learning analysis developed by Siemens and Baker provides a theoretical basis for the in-depth mining of educational data ^[8]. Educational big data analysis technology has experienced a development process from descriptive analysis, diagnostic analysis, to predictive analysis and normative analysis, providing a full chain support for evaluation from “what” to “why” to “what will be” and “what should be done” ^[9]. In recent years, large model technology has shown great potential in the field of educational evaluation. Wang *et al.* have shown that intelligent evaluation systems based on large models can more accurately capture

students' cognitive development trajectory and provide personalized feedback and suggestions^[10]. At the same time, multi-modal data fusion technology makes it possible to deeply understand and analyze unstructured educational data (such as text, images, audio, etc.)^[11].

3. Multi-source heterogeneous data acquisition and processing system

3.1. Data sources and categorization analysis

The basis of constructing an evidence-based value-added evaluation system is to establish a comprehensive teaching platform process data classification framework. In this study, learning data is divided into three categories: (1) learning behavior data, including resource access data (frequency, duration, time distribution), interactive behavior data (speech, question, answer, discussion participation), operation trajectory data (page switching, tool use, annotation behavior), and task completion data (job submission, task progress, cooperative contribution); (2) learning outcome data, including formative assessment data (chapter tests, practical tasks, project performance), summative assessment data (final exam, comprehensive assessment, work results), ability performance data (problem solving, innovative design, communication and collaboration), and development trajectory data (continuous assessment results, growth archives); (3) learning attitude data, including affective state data (learning engagement, expression of interest, mood swings), self-cognition data (learning strategy, self-reflection, goal setting), social data (willingness to cooperate, team role, peer interaction), and value orientation data (learning motivation, career interest, achievement orientation). Student behavior data has a unique value in value-added evaluation: revealing learning habits and styles, providing early warning of learning risks, and discovering hidden tracks of ability development.

3.2. Data standardization processing methods

In order to ensure the quality and availability of multi-source heterogeneous data, this study constructs a data quality assessment and control mechanism that includes six dimensions, including completeness, accuracy, consistency, timeliness, interpretability, and compliance. For the learning behavior data, a standardized model with three layers is designed: the basic layer (unified data format and structure), the semantic layer (unified behavior description and classification), and the application layer (unified analysis index and method).

3.3. Transformation path from data to evidence

The transformation from data to evidence is the core link of evidence-based evaluation. This study established the “data-information-evidence-decision-making” transformation link, and proposed a five-level evidence classification standard: (1) first-level evidence: stable results from randomized controlled experiments; (2) second-level evidence: consistent findings from quasi-experimental studies; (3) third-level evidence: results from cross-validation of multi-source data; (4) fourth-level evidence: regular findings from systematic observation; and (5) fifth-level evidence: conclusions from case studies and expert judgment. In order to ensure the reliability and validity of the evidence, the research adopts a verification mechanism combining triangulation, peer review, and external expert review.

4. Construction of a value-added evaluation agent based on a large model

4.1. Design of value-added index system

The multidimensional value-added index system is the core of evaluation. This research constructs a value-

added index system based on four dimensions: subject knowledge, core competence, learning quality, and comprehensive literacy. The starting point difference calculation model adopts the method of multiple regression and hierarchical analysis, considering the students' basic level, learning conditions, and individual characteristics, and builds an objective value-added benchmark line. The method of expert judgment, data-driven, and large model assistance is adopted to determine the weight of the index to ensure a scientific and reasonable weight distribution.

4.2. Large model-assisted evaluation mechanism

The application of a large model in educational evaluation is mainly reflected in three aspects: data analysis, multi-modal data fusion, and value-added prediction. Especially in the assessment of complex non-cognitive ability, a large model shows the advantages that traditional statistical methods do not have. The value-added prediction and real-time feedback algorithm developed in this study is based on the big model parameter θ , and integrates historical data (H), current state (C), and situational factors (E) to achieve an accurate prediction of students' value-added trend: $\Delta V = f(H, C, E, \theta)$. The prediction results form three types of key information: risk warning, value-added prediction, and intervention suggestions, and transform the technical analysis into concrete feedback that is easy to understand through the natural language generation ability of the large model ^[12].

4.3. Evaluation of agent architecture and implementation

The evaluation agent adopts a “four-layer architecture,” including data layer, model layer, application layer, and interaction layer, and realizes the intelligent processing of the whole process from data collection to result presentation. The core functional modules include a data integration engine, a multidimensional modeling system, an analysis and prediction center, and a personalized feedback generator. All modules work together to form a closed-loop evaluation ecology. The interactive interface of the agent has designed differentiated interfaces for teachers, students, and administrators to meet the needs of different users, while focusing on the simplicity, intuitiveness, and operability of the user experience.

5. Implementation and application of the evidence-based value-added evaluation system

5.1. Operational mechanism of the evaluation system

The operation of the evidence-based value-added evaluation system relies on the “four-in-one” evaluation integration model, which takes teachers, students, system, and managers as the core elements, and forms an organically integrated evaluation ecology by clarifying the responsibilities of all parties and establishing close connections ^[13]. The data-driven evaluation implementation process includes evaluation planning and goal setting, learning starting point data collection, process data continuous collection, agent data analysis and prediction, feedback and intervention, etc., forming a closed-loop optimization path. The application path of evaluation results covers four dimensions, namely individual learning, teaching improvement, school management, and education policy, to ensure that evaluation results can serve different levels of educational decision-making and practice improvement.

5.2. Teaching practice application cases

In this study, the course Data Analysis and Application in colleges and universities is selected as a practical scenario to carry out a one-semester application of the evidence-based value-added evaluation system.

The practical results show that the evidence-based value-added evaluation system has significant effects on improving learning engagement (28.5%), promoting ability development (31.7%), and enhancing learning motivation (25.3%). Following the analysis of typical cases, it is found that there are three kinds of differentiation in ability development of different students: starting point differentiation, value-added differentiation, and development track differentiation. The multidimensional ability analysis of individual students shows that students have significant growth in different ability dimensions (knowledge mastery, problem analysis, tool application, innovative thinking, collaboration ability, and reflection ability), especially in tool application and reflection ability. These findings confirm the concept of personalized education and provide a scientific basis for targeted teaching. The evidence-based value-added evaluation system provides strong support for teachers' decision-making on teaching improvement, helps teachers accurately identify teaching problems, design differentiated teaching strategies, and optimize the allocation of teaching resources ^[14].

5.3. Verification of evaluation effect

The reliability of the evaluation results was tested by triangular verification method, and the results showed that: the internal consistency of the multidimensional value-added index system was high (± 0.83); it is correlated with the traditional evaluation but not completely coincident ($r = 0.76$); high predictive validity for subsequent performance (0.74); and good temporal stability. The acceptance survey of teachers and students of the evidence-based value-added evaluation system shows that the overall acceptance is high (4.21/5), especially in the aspects of fairness, personalization, and supporting learning improvement, which is significantly higher than the traditional evaluation ^[15]. At the same time, it is also found that three aspects of system usability, evaluation results interpretation support, and technical training need to be improved. Based on practice verification and feedback, the study adopted a step-by-step iterative optimization strategy to continuously improve the evaluation system in four aspects of ease of use improvement, explanatory enhancement, technology upgrading, and application expansion, and formed a mature education evaluation solution.

6. Research conclusion and prospects

6.1. Summary of main research results

This research has achieved a series of achievements in three aspects: theoretical framework innovation, technical method breakthrough, and practical application results. At the theoretical level, it constructs a theoretical framework integrating data-driven, evidence-based concepts, and value-added evaluation. At the technical level, the standardization model of learning behavior data, the calculation model of starting point difference, and the value-added prediction mechanism based on a large model are developed. At the practical level, a comprehensive application system covering student learning, teaching improvement, and management support has been formed.

6.2. Research limitations and future research directions

Research limitations are mainly reflected in three aspects: at the theoretical level, the applicability of the subject is limited, and the cross-cultural adaptability is insufficient; at the technical level, the comprehensiveness of data is still challenged, and the interpretability of large models is insufficient; at the application level, the sample representation is insufficient, and the promotion conditions are high. Future research can be further explored in four directions: theoretical expansion (interdisciplinary theory integration, evaluation ethics theory construction), technical deepening (multi-modal perception technology, causal inference model), application

expansion (basic education adaptation, vocational education application), and policy support (standard and norm research, evaluation policy innovation), so as to jointly build a more complete evidence-based value-added evaluation ecosystem. In short, the research on the evidence-based value-added evaluation system based on data-driven is a frontier field full of challenges and opportunities. Future research needs to pay more attention to the educational value and humanistic care of evaluation while promoting the progress of evaluation technology, so as to truly realize the reform goal of “people-oriented” education evaluation.

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Disclosure statement

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Exploration of the Construction Path of Ideological and Political Education in Software Technology Courses at Vocational Colleges

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Abstract: The *Guidelines for the Construction of Ideological and Political Education in Courses at Institutions of Higher Learning* emphasizes that “the construction of ideological and political education in courses is an important task for comprehensively improving the quality of talent cultivation” and “clarifying the target requirements and key content of the construction of ideological and political education in courses.” In vocational colleges, as an important discipline in the field of information technology, the construction of ideological and political education in software technology courses is of great significance for cultivating students’ comprehensive qualities and establishing correct values. Based on sorting out the core literacy of the construction of ideological and political education in software technology courses, this article actively explores its construction path, hoping to provide references for relevant educators.

Keywords: Software technology major; Ideological and political education in courses; Vocational colleges

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1. Introduction

With the rapid development of information technology, the software technology major is playing an increasingly prominent role in vocational colleges. As an important base for cultivating high-quality information technology talents, vocational colleges should not only impart professional knowledge and skills in software technology teaching but also pay attention to students’ ideological and political education, achieving the organic unity of knowledge imparting and value guidance^[1]. Therefore, exploring the construction path of ideological and political education in software technology courses at vocational colleges is of great significance for improving the quality of talent cultivation and promoting students’ all-round development. This article will start from the core elements of the construction of ideological and political education in courses and deeply analyze the specific implementation paths of the construction of ideological and political education in software technology courses.

2. Core elements of the construction of ideological and political education in software technology courses

Essentially, the construction of ideological and political education in software technology courses means integrating the core ideological and political education elements that are most needed to be shaped and most relevant to the major into the teaching of professional courses, so as to guide students to establish correct values, improve their thinking abilities, and promote the innovation and renewal of educational concepts. Combining the characteristics of software technology courses and the educational goals, the core literacy of the construction of ideological and political education in its courses is sorted out as follows.

2.1. Political identity and patriotic sentiment

Political identity and patriotic sentiment are the fundamental elements in the process of ideological and political education in software technology courses. With the development of information technology and its deep integration into various fields and industries, it has become a key area of national strategic competition. In the teaching process of software technology courses, teachers should guide students to deeply understand the connotation of “self-reliance and self-improvement in science and technology” in the new era. For example, by guiding students to compare the technical development histories of Windows and the domestic Kylin operating system, and analyzing the innovative path of Huawei’s Hongmeng system in breaking through the Android ecosystem blockade, students can fully understand the strategic significance of independent and controllable core technologies^[2]. In the teaching process of “Database Technology,” teachers can introduce the development case of the “Health Code” system, explaining how China’s independently developed big data platform for epidemic prevention and control processed an average of 60 billion pieces of data per day during the epidemic, covering 1.4 billion people and effectively supporting social governance, thus fully demonstrating the advantages of the socialist system with Chinese characteristics^[3]. In addition, teachers can have students compile the “Timeline of China’s Scientific and Technological Rise” project based on major scientific and technological achievements such as the Beidou Navigation System and quantum communication, and present the development context of national science and technology through visual programming technology, so as to stimulate students’ national pride^[4]. Teachers can also have students participate in the practical task of designing “Red Code,” and require them to integrate red culture elements when writing the modules of the government service platform, such as using Python to draw a dynamic pattern of the Party emblem, thus achieving the deep integration of professional skills and value guidance.

2.2. Professional ethics and legal awareness

The professional behaviors of software technology talents directly affect information security and social stability, so the cultivation of professional ethics and legal awareness is of particular urgency. In the Network Security Technology course, teachers can introduce cases such as the “Panda Burned Incense” virus case and the Facebook data-leakage incident, and analyze the relevant provisions of the “Network Security Law” and the “Data Security Law” to strengthen students’ awareness of the legal bottom line^[5]. In the Software Engineering course, teachers can introduce the “Microsoft Windows XP End-of-Support Event” and guide students to discuss how to balance user rights and social responsibilities when an enterprise terminates the maintenance of an old system due to commercial interests. Students are required to write an ethical decision-making report based on the “Measures for the Management of Software Products”^[6]. Regarding artificial intelligence ethics issues, an “Algorithm Bias Detection” experiment can be set up in the Machine Learning course. Teachers can guide students to use public datasets to verify the recognition-difference rates of face-recognition systems

for different ethnic groups, enabling them to understand the necessity of writing fairness-optimized code. On this basis, schools can establish a “Technical Ethics Review Committee,” with professional teachers, legal consultants, and enterprise experts jointly evaluating students’ projects and assessing the compliance of app development plans involving user privacy collection.

2.3. Scientific morality and innovation spirit

In view of the academic misconduct risks, such as code plagiarism and data fraud, in the software technology field, it is necessary to construct a cultivation system for scientific morality and innovation spirit. In the Fundamentals of Programming course, teachers can deploy a code-plagiarism-checking system (such as MOSS) to detect the similarity of final-term projects. Students with a repetition rate exceeding 30% need to restructure their code and participate in academic-norm training. Teachers can also carry out the Innovative Algorithm Marathon activity, requiring students to use genetic algorithms to solve traffic-congestion problems^[7]. In the teaching of “Introduction to Artificial Intelligence,” teachers can guide students to compare the technical differences between AlphaGo and the domestic Go AI “Jueyi,” and analyze the algorithm innovation points of the open-source papers of the DeepMind team, so as to cultivate students’ awareness of respecting intellectual property rights. A “Contribution-point System for Open-source Communities” can be established, and participation in international open-source projects such as Apache and Linux can be included in the course assessment.

2.4. Professional morality and work ethic

In view of phenomena such as the “996 work system” and “age anxiety” in the software industry, it is necessary to further strengthen the cultivation of professional morality and work ethic among software technology majors. In the Software Testing Technology course, teachers can simulate the real-world stress-testing scenarios of enterprises: execute 2,000 automated test scripts continuously for 8 hours and record the change curve of students’ error rates, guiding them to understand the balance between efficient work and reasonable rest. Teachers can also introduce the “Programmer’s Occupational Health” module into the course content, explain the preventive measures for tendinitis and cervical spondylosis, and organize the “Standing-Style Programming” experience activity. In the Project Management course, an “Agile Development Practice” can be set up, requiring students to complete the development of the “Campus Food Delivery System” in groups within two weeks and report their work progress and difficulties daily while standing, so as to cultivate team cooperation and stress resistance abilities^[8]. Teachers can carry out the activity of “Model Worker Engineers Entering the Classroom,” alumni who have won the title of “National Technical Expert” are invited to share their experiences in software debugging and tell stories of continuous problem-solving. A “Code Craftsman” evaluation system can be established, with code-standardization (in accordance with the PEP8 standard), unit-test coverage rate (required to reach over 85%), and document integrity included in the assessment indicators, and an “Excellence Award” can be issued to students.

3. Construction paths of ideological and political education in software technology courses

3.1. Constructing a “trinity” of ideological and political education in the course system

The construction of ideological and political education in software technology courses requires the construction of a coordinated “trinity” system of “goal leading, curriculum restructuring, and resource supporting.” First, strengthening the goal leading of top-level design. According to the *Guidelines for the Construction*

of Ideological and Political Education in Courses at Institutions of Higher Learning and combined with the professional talent cultivation plan, a three-dimensional matrix of “knowledge goals, ability goals, and ideological and political goals” is formulated ^[9].

Secondly, promoting the structural restructuring of the curriculum system. It is necessary to break the traditional disciplinary barriers and integrate ideological and political elements into the entire chain of “basic courses, core courses, and expansion courses”; embed the education of the history of science and technology in professional basic courses, such as China’s contributions to the development of computers; add a “Technical Ethics” special module to core courses, such as discussing algorithm bias issues in the Python Data Analysis course; develop “Red IT” elective courses in expansion courses ^[10]. On this basis, an inter-course ideological and political linkage mechanism is established. For example, the “Software Testing” and “Professional Accomplishment” courses can jointly carry out the theme discussion of “Defect Repair and Sense of Responsibility.”

Finally, improving the resource-supporting system. Three types of resources are built: an “ideological and political education in courses case library,” a “virtual simulation project library,” and a “school-enterprise collaborative education platform.”

3.2. Innovating the “multi-teacher collaboration” teaching mode

The construction of ideological and political education in software technology courses can be achieved by establishing a multi-teacher collaborative system mechanism of “professional course teachers + ideological and political teachers + enterprise mentors,” breaking the “two skins” of professional teaching and ideological and political education.

Firstly, building a diverse teaching team. Schools can form a mixed teaching team consisting of teachers from the ideological and political department, software technology professionals, and enterprise engineers to carry out collective lesson preparation for “technology + ideological and political education” ^[11].

Secondly, implementing a multi-teacher co-teaching model. At key teaching nodes, implement multi-teacher linkage teaching, and carry out “knowledge explanation + technical analysis + ideological sublimation” ^[12]. Taking the core course Mobile Application Development as an example, when teaching the “principle of minimizing permissions,” the professional course teacher can explain the Android architecture, the ideological and political teacher can analyze the value deviation behind the “excessive power claim of app,” and the enterprise mentor can share the formal software development process, thus constructing a “multi-teacher collaboration” teaching mode, so that students can not only firmly grasp professional skills, but also deeply improve their ideological and political literacy.

Thirdly, deepening the integration of industry and education and promoting collaborative education. Transform real enterprise projects into carriers of ideological and political education, and establish a transmission chain of “project practice professional norms value cultivation.” For example, in the development of the “Smart Agriculture Internet of Things System” through school enterprise cooperation, enterprise mentors guide students to overcome the technical difficulties of sensor networking and simultaneously implant “technology-assisted agriculture” responsibility education. In the process of contributing code to open-source communities such as OpenHarmony, enterprise mentors emphasize the open-source spirit of “open sharing, collaborative innovation” through code review, enabling students to achieve synchronous improvement of technical skills and professional spirit in real production environments.

3.3. Creating a virtual-real integration ideological and political education scenario

In view of the strong abstractness of software technology and the difficulty of integrating ideological and political education, it is necessary to construct a three-dimensional education scenario of “virtual simulation + on-site experience + digital platform.” In terms of virtual scenario construction, develop VR/AR teaching resources with ideological and political connotations. For example, use virtual simulation technology to restore the “Loongson Processor R&D Laboratory” to let students “immersively” experience the process of core technology research and development. Design the “Data Ethics Maze” interactive game, and through role-playing as data engineers, hackers, regulators, etc., students can deal with moral dilemmas such as privacy leakage and algorithmic discrimination, and strengthen their ethical awareness through virtual decision-making^[13].

In terms of on-site education scenarios, create a linkage mechanism for “three types of classrooms.” Build an “IT Culture Corridor” on campus to display the technological evolution history from the abacus to the quantum computer, highlighting the main line of “scientific and technological innovation driving the progress of civilization.” Establish red-IT practice bases off-campus, organize visits to national super-computing centers and Beidou satellite industrial parks, and carry out the theme research of “The Power of China in Code.” Build an “Online Programmers’ Values Discussion Area” in the cloud, and conduct debates around hot topics such as the “996 work system” and the “35-year-old career crisis” to form a value-shaping field that integrates online and offline.

In terms of digital platform empowerment, construct an intelligent ideological and political management system. Use big data technology to collect students’ learning behavior data, such as code submission records and online discussion content. Through an emotion analysis model, identify students’ value orientation tendencies, and automatically push warning cases to students with behaviors such as “code plagiarism” and “negative collaboration.” Develop a “Growth Record of Ideological and Political Energy Values,” convert practical experiences such as participation in open-source projects and technical public welfare services into visual points, and stimulate students’ internal motivation to actively construct values.

3.4. Establishing a multi-element coupling evaluation mechanism

The evaluation of the effectiveness of ideological and political education in courses needs to break through the single-knowledge assessment model and construct a coupled evaluation system with “multiple subjects, multiple dimensions, and diverse methods.” In terms of evaluation subjects, a four-dimensional linkage of “students’ self-evaluation, teachers’ mutual evaluation, enterprise participation in evaluation, and third-party evaluation” is formed. For example, in the Software Engineering Practice course, students record their ethical thinking in technical decision-making through the “Integrity Development Log.” School-enterprise dual mentors jointly score from three dimensions: code standardization, team cooperation, and social value. Industry associations are introduced to certify the compliance of project results to ensure the objectivity of evaluation.

In terms of evaluation content, a three-level index system of “value cognition, emotional identification, and behavioral externalization” is established. In the assessment of the Front-end Development course, not only is the mastery of HTML5 skills tested, but also the service awareness is examined through practical projects, and the social benefits are evaluated based on the user feedback after the project is launched. On this basis, teachers can also develop an “ideological and political radar chart” evaluation tool to generate student growth portraits from six dimensions, including political literacy, legal concept, and innovation spirit, so as to achieve precise education^[14].

In terms of evaluation methods, a combination model of “process evaluation, value-added evaluation, and

development evaluation” is adopted. In addition to traditional written examinations, “ideological and political education in courses defense meetings” (displaying the values reflected in technical projects) are added, “growth portfolio evaluations” (collecting process materials such as ethical reflections in code annotations and technical public-welfare certificates) are implemented, and “value concept tracking surveys” of graduates (analyzing the degree of fit between career choices and national strategic needs) are carried out. The evaluation results are fed back to the revision of the talent cultivation plan, thus forming a dynamic optimization mechanism of “evaluation–improvement–re-evaluation” to ensure that the construction of ideological and political education in courses is always in line with industry development and national needs.

4. Conclusion

Vocational college software technology majors can strengthen the construction of ideological and political education in courses by constructing a “trinity” ideological and political education in courses system, innovating the “dual-teacher collaboration” teaching model, creating a “virtual-real integration” ideological and political education scenario, and establishing a “multi-element coupling” evaluation mechanism. This can cultivate students’ political identification and patriotic sentiment, enhance their professional ethics and legal awareness, scientific morality and innovation spirit, so as to better meet the continuous development of information technology and the growing national demand for software technology talents, and contribute to the cultivation of more new-era software engineers with noble virtues and excellent skills.

Disclosure statement

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Analysis of Influencing Factors of Academic Warning in Higher Vocational Colleges Based on the Importance of Machine Learning Features and Paths to Improve Learning Ability

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Abstract: The traditional academic warning methods for students in higher vocational colleges are relatively backward, single, and have many influencing factors, which have a limited effect on improving their learning ability. A data set was established by collecting academic warning data of students in a certain university. The importance of the school, major, grade, and warning level for the students was analyzed using the Pearson correlation coefficient, random forest variable importance, and permutation importance. It was found that the characteristic of the major has a great impact on the academic warning level. Countermeasures such as dynamic adjustment of majors, reform of cognitive adaptation of courses, full-cycle academic support, and data-driven precise intervention were proposed to provide theoretical support and practical paths for universities to improve the efficiency of academic warning and enhance students' learning ability.

Keywords: Academic warning; Pearson correlation coefficient; Random forest variable importance; Permutation importance

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1. Introduction

With the popularization of higher education and the promotion of the policy of expanding enrollment, the source structure of students in higher vocational colleges has become increasingly diversified. Some students have fallen into academic difficulties due to a weak academic foundation, a lack of self-control, and environmental interference. The *Outline of the National Medium- and Long-Term Education Reform and Development Plan (2010–2020)* clearly requires the establishment of a support mechanism for students with learning difficulties^[1], highlighting the urgency of building an academic early warning mechanism. As an innovative means of teaching management, academic early warning helps students get back on track through dynamic monitoring and graded

intervention ^[2], and the penetration of big data technology provides a new path for accurately identifying early warning factors.

In recent years, machine learning (ML) technology has shown significant potential in biology, materials science, education, and other fields. Jia and Sun ^[3] established a model of mutant protein amino acid sequence and spectral maximum absorption wavelength through ML and obtained a prediction coefficient R^2 of 0.944. He *et al.* ^[4] used feature quantity screening to identify key alloy factors affecting alloy properties and established an alloy prediction model to achieve rapid design of alloy composition. Wang ^[5] constructed an academic warning model through ensemble learning, with an accuracy rate of 80.96%; variable importance analysis verified its ability to explain complex associations in fields such as biology and materials science. In the field of education, existing research focuses on undergraduate education, and quantitative analysis of warning factors for the characteristics of higher vocational and technical college students is still insufficient.

Based on the academic data of the former Guangxi College of Education from 2016 to 2021, this study integrates ML variable importance evaluation methods to analyze the influencing factors of academic warning for higher vocational and technical colleges. Compared with traditional statistical methods, this technology can capture nonlinear relationships and quantify the contribution of each factor, helping to improve the effectiveness of teaching management and providing a certain scientific basis and practical foundation for improving learning ability.

2. Evaluation indicators of factors affecting academic warning

The Pearson correlation coefficient (PCC) quantifies the strength and direction of the linear association between two variables by measuring the ratio of the covariance of two variables to their respective standard deviations. The value (r) range of the correlation coefficient is between -1 and 1. When the two variables are positively correlated, r is between 0 and 1; when they are negatively correlated, r is between -1 and 0; if $r = 0$, it indicates that there is no linear correlation between x and y , that is, linear independence. The larger the absolute value of the correlation coefficient, the stronger the correlation; the closer the absolute value of the correlation coefficient is to 0, the weaker the correlation ^[6]. This coefficient eliminates the influence of dimension through standardization and is suitable for evaluating the closeness of linear patterns between variables, but it cannot capture nonlinear relationships or causal relationships.

Random forests variable importance (RFI) ^[7] is based on the Gini impurity reduction method. They measure the contribution of features to model prediction by calculating the average change in the Gini coefficient when the feature is split across all decision tree nodes. Their advantages include resistance to overfitting, high stability, and suitability for nonlinear relationship modeling ^[8].

Permutation importance (PI) ^[9] evaluates the contribution of a feature to model prediction by destroying the original association between the feature and the target variable. Specifically, this method assumes that if a feature is critical to the model, the model's prediction performance will drop significantly when its value is randomly perturbed; conversely, if the performance does not change much, it means that the feature is less important. The benefit of this technique is that it does not depend on the model and can be calculated multiple times with different permutations of the feature.

3. Analysis of factors affecting academic warning

The data set consists of the grade warning information of the four schools of the former Guangxi College of

Education from the second semester of the 2016–2017 school year to the first semester of the 2021–2022 school year. Only the grade warning data in the academic warning information is analyzed. The academic warning mentioned below refers to the grade warning. The data set contains 2,022 samples, and the feature variables are warning level, school, major, and grade. The schools are the School of Mathematics & Information Sciences, the School of Educational Sciences, the School of Languages & Literature, and the School of Arts. The warning levels are divided into yellow warning, orange warning, and red warning from low to high according to the number of students who fail the exams, covering three grades of higher vocational college students. The following analyzes the relationship between feature variables and warning levels through traditional statistical methods and ML variable importance evaluation.

3.1. Comparison of methods and differences in explanatory power

Figure 1 shows the PCCs between the warning level and the characteristic variables. It can be seen that the PCC between the major and the school is 0.394, close to 0.5, indicating that there is a certain correlation between the two, which is basically consistent with the division principle of majors and schools. However, the linear correlation between each characteristic variable and the warning level is lower than 0.5, and the linear model is difficult to capture complex relationships. In view of this, the RFI and PI methods based on machine learning technology are used for analysis, and the results are shown in Figure 2.

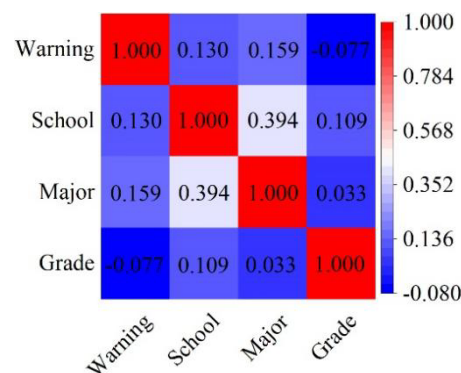


Figure 1. PCCs between warning level and characteristic variables

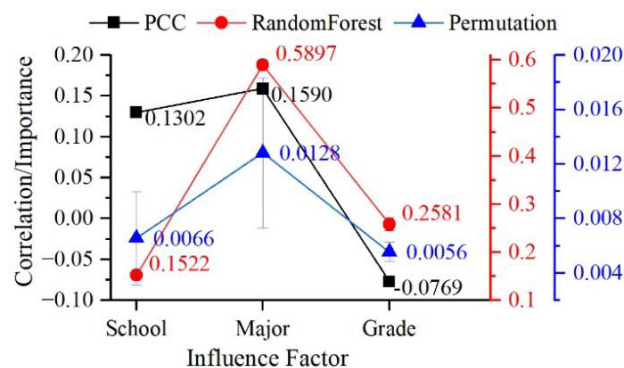


Figure 2. Evaluation of the importance of warning level characteristics

The larger the value of feature importance evaluation, the greater the impact of the feature on the student warning level. As shown in Figure 2, the importance score of the major feature (0.5897) is significantly higher than other variables, which verifies the advantage of variable importance analysis in processing high-

dimensional heterogeneous educational data. It is worth noting that the consistency of the results of random forest and permutation importance methods (major > grade > school) shows that the nonlinear model has a higher stability in feature sorting.

3.2. Analysis of the characteristics of the major

For art majors, students majoring in music, dance, etc., have a high failure rate in theoretical courses due to long-term art training (average professional training time per day ≥ 4 hours), and their awareness of rules is weak^[10]. There is a general cognitive bias of “focusing on skills rather than theory,” and there is a structural imbalance in learning input.

For the School of Educational Sciences, the number of students majoring in primary school general education accounts for the highest proportion. This major is a five-year junior high school-based higher vocational education. The high school management method is fully adopted in terms of academic style construction, teacher-student communication, etc., so that students’ learning status is significantly better than that of students in other majors. They have stronger learning ability, are more likely to accept teacher guidance, have a low failure rate, and naturally have fewer academic warnings. However, we need to be vigilant against excessive management that weakens students’ independent learning ability.

For science and engineering majors, the knowledge density of the courses in the School of Mathematics and Information Sciences is high, and there is a strong dependence between courses. There are a lot of calculations and knowledge points to remember. The combination of these two aspects leads to a significant increase in the difficulty of the courses, which easily leads to an increase in the number of failures in professional courses.

For liberal arts majors, students in the School of Language and Literature need to cope with both theoretical recitation and practical assessments, such as teacher qualification certificates, and their cognitive load index is significantly higher than that of other majors. This has resulted in the college’s failure rate being second only to that of the School of Arts, and showing a “polarization” feature.

4. Optimization strategies for academic warning and paths to improve learning ability

Traditional post-event warnings have poor timeliness and need to shift to pre-event prediction and intervention, and improve academic performance and learning ability with the concept of “student-oriented.” The specific countermeasures are as follows.

Building a three-dimensional model of “regional industry demand–professional competitiveness–warning rate,” dynamically adjusting the course structure of high-warning majors such as arts, piloting the mechanism of replacing general credits with art competitions, and promoting the establishment of interdisciplinary integration courses in liberal arts majors, transforming recitation tasks into project practice, and alleviating the conflict between professional training and theoretical learning.

Carrying out cognitive adaptation reform of the curriculum system, building a knowledge map navigation system for science and engineering, and monitoring the risk of knowledge gaps in real time; implementing “theory + practice” modular assessment for liberal arts, allowing students to choose the difficulty of tasks independently, and balance the fairness and challenge of learning.

Establishing a full-cycle academic support mechanism with three-level intervention of “entrance assessment–behavior monitoring during the semester–targeted counseling before the exam,” identifying high-

risk students through the “Academic Adaptability Scale,” and dynamically adjusting the warning threshold based on self-study time and test data; building a student portrait platform that integrates academic affairs, behavior, and social data to achieve automatic warning and precise resource push.

Integrating multi-source data, such as the teaching system and course platform, to build an early warning information management platform. Generating personalized learning plans through time management diagnosis and cognitive style assessment to cultivate self-regulation ability, gradually improve learning ability, and reduce the repeated warning rate. Studies by Zhao and Zhao ^[11], Lv and Xia ^[12] have confirmed that multidimensional data fusion can significantly improve the explanation of early warnings and the effectiveness of interventions.

5. Conclusion

This study established a data set for academic early warning information and revealed the deep mechanism of academic early warning in higher vocational colleges through PCC, RFI, and PI analysis methods. Data analysis found that machine learning methods broke through the limitations of traditional statistics and effectively captured nonlinear relationships. The majority of students in the academic early warning data was the core driving factor of academic early warning, with an importance score of 0.5897. Among them, art majors had the highest failure rate due to “focusing on skills and neglecting theory,” while the School of Education Science controlled the warning rate to the lowest through high school-style refined management of students in general classes, but it is also necessary to be vigilant about the suppression of student autonomy by management rigidity. Based on this, countermeasures such as dynamic adjustment of majors, reform of cognitive adaptation of courses (such as knowledge graph navigation, modular assessment, etc.), full-cycle academic support of the three-level intervention system and data-driven precise intervention were proposed to form a closed loop of “problem identification–technology empowerment–strategy iteration” and promote the transformation of academic early warning from “after-the-fact remediation” to “pre-emptive prevention.” In the future, it is necessary to conduct an in-depth analysis on data richness, combining multi-center data with dynamic models, etc. This study provides guidance for colleges and universities that offer higher vocational and technical majors to improve academic warning methods and enhance learning ability, and provides a data-driven decision-making framework for optimizing teaching management, which has important practical value for implementing the goal of “precision education.”

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From Design to Implementation: A Study on Quality Assurance of Cultural Study Courses in Vocational Colleges Based on the AOL System

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Abstract: With the development of vocational education, cultural study courses play an increasingly important role in cultivating students' overall competence and professional skills. However, many vocational colleges face challenges such as outdated teaching content, low student engagement, and insufficient learning outcomes in their cultural study courses. To address these issues, this study introduces the Assurance of Learning (AOL) system, aiming to enhance course quality through a systematic approach. Using Shanghai Zhongqiao University of Technology and Vocational Education as a case study, this research explores the specific pathways for designing and implementing cultural study courses based on the AOL system. During the course design phase, specific and measurable learning objectives are set, and corresponding teaching content and assessment tools are developed to enhance the controllability of the study process. In the implementation phase, various teaching strategies such as project-based learning, case analysis, and field visits are adopted to promote active student participation and effective learning. Additionally, continuous monitoring and feedback mechanisms are employed to continuously adjust and optimize the course content and teaching methods. This study not only provides specific pathways for course improvement in vocational colleges but also verifies the effectiveness of the AOL system in enhancing the quality of cultural study courses. The research findings offer valuable references for other vocational colleges in curriculum reform and quality improvement.

Keywords: AOL system; Cultural study courses; Vocational colleges

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1. Introduction: Research background and significance

Culture, as the most unique spiritual symbol of a nation and country, is an essential part of every citizen's duty and responsibility to learn, inherit, and develop. It is also a fundamental aspect of educational activities, playing a crucial role in fostering national consensus, enhancing cultural confidence, and boosting national cultural soft power ^[1]. As vocational education continues to evolve, cultural study courses have become increasingly important in cultivating students' overall competence and professional skills. These courses serve as an

innovative form of bridging school education with extracurricular education and provide an effective pathway for comprehensive practical education. Cultural study courses promote communication and collaboration among students, encourage cooperation and mutual assistance, enhance innovation and creativity, and improve cultural understanding, thereby embodying the internationally recognized 5C core competencies: cultural understanding and inheritance, critical thinking, innovation, communication, and collaboration ^[2].

Currently, some vocational colleges face challenges in their cultural study courses due to a lack of top-level design, insufficient support, and outdated teaching methodologies. This has led to issues such as unclear research objectives, overemphasis on form rather than substance, lack of structured processes, low student engagement, and inadequate learning outcomes. As a result, these courses fail to achieve their educational and developmental goals and lead to the waste of both teaching and social resources ^[3].

Existing research emphasizes addressing these issues from various perspectives, such as the societal, institutional, teacher, and student dimensions. However, there is a lack of in-depth studies focusing on the design and implementation of cultural study courses themselves. This study introduces the Assurance of Learning (AOL) system, aiming to enhance the quality of cultural study courses through a systematic approach. Based on the AOL framework, cultural study courses are designed as a continuous improvement process that includes setting learning objectives, implementing and measuring these objectives, evaluating learning outcomes, and maintaining a cycle of continuous improvement ^[4]. This approach can significantly enhance the teaching quality and learning effectiveness of cultural study courses.

2. Design and implementation of cultural study courses based on the AOL system

2.1. Course design

2.1.1. Setting multi-dimensional, measurable learning objectives

Based on the core principles of the AOL system and the characteristics of vocational education, the main goal dimensions for cultural study courses should be determined. These dimensions include, but are not limited to, knowledge acquisition, skill development, attitudes and values, social competence, and innovation. For each goal dimension, specific and clear learning outcomes should be established. These outcomes should be concrete, measurable, and verifiable through assessment tools ^[5].

Knowledge acquisition: For example, objectives can be set such as “students will be able to identify and analyze the characteristics and conservation significance of at least five cultural heritage sites,” or “students will be able to accurately describe and explain at least three important historical events from different cultural backgrounds and their impacts” ^[6].

Attitudes and values: For example, an objective could be “students will be able to express respect and understanding for diverse cultures in discussions and actively participate in intercultural exchange activities.”

Innovation: For example, an objective could be “students will propose at least two creative solutions to improve existing cultural products and conduct preliminary design and justification” ^[7].

Additionally, to ensure the measurability of learning outcomes, detailed assessment criteria should be developed for each outcome, with timely feedback and adjustments provided to both students and instructors ^[8]. This approach helps track progress and ensures that the course objectives are met.

2.1.2. Planning thematic and targeted teaching content

On one hand, the teaching content should be selected based on the learning objectives established earlier. The content for each goal dimension should be specific, targeted, and coherent. For example, to achieve the

objective of helping students understand certain historical cultures, representative historical events, figures, and cultural heritage sites can be chosen to help students grasp the origins and development of different cultures ^[9]. To enhance students' teamwork and public speaking skills, tasks that require collaboration can be designed, such as group projects and team competitions. Additionally, opportunities should be provided for students to showcase their learning outcomes in public settings, such as through presentations, reports, and performances, thereby boosting their confidence and communication abilities ^[10].

On the other hand, the selection of teaching content should also fully consider students' interests and career development directions. Teachers can gather information about students' interests through surveys and interviews. They can also tailor the cultural study content to the characteristics of vocational college students by aligning it with their professional backgrounds and future career plans, ensuring that the content is both engaging and relevant.

2.1.3. Arranging flexible and diverse teaching activities

Arranging flexible and diverse teaching activities is crucial to ensuring that students can actively participate, learn effectively, and achieve the course objectives. When designing these activities, several key principles should be followed:

Student-centered: Activities should encourage active participation and autonomous learning, promoting students' critical thinking and exploration.

Practice-oriented: Through hands-on and experiential learning, students should be able to apply their knowledge and skills in real-world contexts.

Diverse interaction: A variety of interactive formats are designed, such as group discussions, role-playing, and project collaborations, to enhance students' communication and teamwork skills.

Assessment and feedback: Each activity should include an assessment component, providing timely feedback to help students improve and advance.

When planning teaching activities, instructors can flexibly choose from a range of options based on the course goals and content. These may include:

- (1) Lectures and discussions (e.g., specialized lectures, group discussions)
- (2) Practical operations and experiences (e.g., handicraft making, field visits)
- (3) Project-based learning (e.g., creative design, community service)
- (4) Cross-cultural exchange (e.g., role-playing, cultural dialogues)
- (5) Reflection and summarization (e.g., reflection journals, group presentations)

By adhering to these principles and selecting appropriate activities, instructors can create a dynamic and engaging learning environment that supports the achievement of course objectives.

2.1.4. Establishing a robust assessment and feedback mechanism

Developing an assessment strategy is a critical component to ensure that course objectives are met and student learning outcomes are effectively measured. The assessment strategy should be comprehensive, multi-dimensional, and capable of providing immediate feedback to facilitate continuous improvement for both students and instructors ^[11]. When formulating the assessment strategy, the following key principles should be adhered to:

Multi-dimensional: Assessments should cover multiple aspects of learning, including knowledge, skills, attitudes, and practical abilities.

Measurable: Learning outcomes should be specific and quantifiable, allowing for clear evaluation.

Process and outcome-oriented: Both the learning process and final outcomes should be assessed to provide a balanced evaluation.

Diverse: A variety of assessment methods should be used to cater to different learning styles and strengths.

Timely feedback: Feedback should be provided promptly to help students improve and adjust their learning strategies.

When developing assessment content and criteria, it is important to consider the characteristics and professional backgrounds of vocational college students, ensuring that the assessment standards are appropriately challenging yet achievable. Additionally, instructors can employ a range of assessment methods:

Formative assessment: Conducted after each activity, using methods such as surveys, interviews, and observations to gauge student progress and gather feedback. This allows for timely adjustments to teaching strategies.

Summative assessment: Performed at the end of the course, using methods such as exams, reports, and project presentations to comprehensively evaluate student learning outcomes.

Peer assessment: Encouraging students to assess each other, fostering mutual learning and improvement.

Self-assessment: Guiding students to reflect on and evaluate their own learning, promoting self-directed learning and personal growth.

By implementing these assessment and feedback mechanisms, instructors can create a structured and supportive learning environment that helps students achieve their learning goals and continuously improve.

2.2. Course implementation: A case study of cultural study activities at Shanghai Zhongqiao University of Technology and Vocational Education

2.2.1. Preparations before course implementation

Before the official start of the course, a series of preparations need to be carried out to ensure the smooth implementation of the course^[12]. Specifically, these preparations include:

Teacher training: The cultural study courses at Shanghai Zhongqiao University of Technology and Vocational Education typically involve collective lesson planning activities for instructors. This ensures that teachers understand the requirements of the AOL system, the objectives and content of the cultural study courses, as well as the assessment criteria. This helps to unify teaching concepts and ensure the coherence and consistency of the course^[13].

Resource preparation: Prior to the start of the study activities, necessary materials such as textbooks, teaching aids, multimedia resources, etc., should be prepared to ensure the smooth operation of teaching activities. For example, arranging transportation for visits to museums or cultural sites, and preparing materials for handicraft making.

Student mobilization: Before the study activities begin, teachers at Shanghai Zhongqiao University of Technology and Vocational Education introduce the course objectives, content, and assessment methods to students through class meetings, lectures, and other forms. This aims to stimulate students' interest and enthusiasm for learning.

Environment setup: Based on the course content, classrooms or activity venues are arranged to create a rich cultural atmosphere. For example, posting pictures related to traditional culture and displaying handicrafts.

By thoroughly preparing in these areas, the university ensures that all aspects of the course are well-organized and ready for effective implementation.

2.2.2. Monitoring and feedback during implementation

During the course implementation, it is essential to establish effective monitoring and feedback mechanisms to promptly understand students' learning progress and any issues they encounter, and to provide necessary support and guidance. At Shanghai Zhongqiao University of Technology and Vocational Education, the following practices are employed in the cultural study courses:

Classroom observation: Teachers observe and record students' participation, interaction, and their performance in asking and answering questions. This helps in assessing the level of student engagement and identifying areas where additional support may be needed.

Immediate feedback: After each teaching activity, teachers provide immediate feedback, highlighting the strengths and areas for improvement for each group of students. They also offer constructive suggestions to help students enhance their learning outcomes.

Group discussions: Teachers encourage students to share their learning experiences and challenges through group discussions. This promotes communication and collaboration among students, fostering a supportive learning environment.

Peer assessment: After activities, teachers organize peer assessments, where students evaluate each other's work. This helps develop students' sense of cooperation and evaluation skills.

Reflection journals: Students are required to regularly write reflection journals, documenting their learning achievements and reflections. This practice encourages self-reflection and summation, helping students to internalize their learning experiences ^[14].

Through these monitoring and feedback mechanisms, teachers can ensure that students receive timely support and guidance, enhancing the overall effectiveness of the course.

2.2.3. Evaluation and reflection after implementation

At the end of the course, a comprehensive evaluation and reflection are conducted to summarize the experiences and lessons learned from the course implementation, providing a basis for future improvements. Taking the cultural study activities at Shanghai Zhongqiao University of Technology and Vocational Education as an example, after the semester-long course concludes, the university collects feedback from students through surveys, interviews, and other methods. This feedback covers various aspects such as course content, teaching methods, and activity arrangements, helping to gauge student satisfaction and gather their suggestions.

Based on this feedback, teachers summarize the entire course implementation process. They analyse the effectiveness of teaching activities, evaluate student learning outcomes, and identify any problems and challenges encountered. Additionally, teachers are required to compile and analyse data such as student exam scores, assignment completion, and project presentation results to assess the achievement of course objectives.

2.2.4. Exhibition and promotion of outcomes

At the end of the course, having students showcase their learning outcomes not only enhances their sense of achievement but also provides valuable references and examples for other schools and educators. For instance, after the completion of the cultural study courses at Shanghai Zhongqiao University of Technology and Vocational Education, the university selects outstanding works to host small cultural exhibitions. These exhibitions display students' handicrafts, creative design projects, and other achievements, inviting parents, teachers, and other students to visit.

The university also encourages students to further refine their work and participate in city-level and

national competitions. Through seminars, workshops, and presentations, teachers and students share their experiences and insights from the course implementation, fostering exchange and collaboration among education professionals.

Furthermore, the university contacts local media to report on the process and outcomes of the course, expanding its social impact and enhancing the school's reputation and recognition. This multifaceted approach to showcasing and promoting student achievements helps to highlight the quality and effectiveness of the educational programs, benefiting both the students and the institution ^[15].

3. Quality assurance and continuous improvement measures for cultural study courses based on the AOL system

3.1. Internal quality control measures

Internal quality control refers to the monitoring and improvement measures taken by the school during the course design, implementation, and evaluation processes to ensure the achievement of course objectives.

Course design review: Invite both internal and external experts to review course objectives, teaching content, and assessment criteria to ensure they meet the requirements of the AOL system.

Peer evaluation: Organize peer reviews among teachers, where they provide each other with feedback and improvement suggestions to enhance the quality of course design.

Teacher training and support: Organize professional training sessions for teachers to improve their teaching skills and assessment abilities; provide ongoing technical support and teaching resources.

Teaching observation: Arrange for teachers to observe excellent instructors, learning from their teaching methods and experiences to promote improvements in teaching quality.

Teaching resource management: Ensure that necessary materials, teaching aids, multimedia resources, etc., are available on time and regularly updated and maintained to meet teaching needs. Introduce modern educational technologies such as virtual reality and online learning platforms to enrich teaching methods and enhance teaching effectiveness.

Student feedback mechanism: Establish multiple channels for student feedback, such as surveys, suggestion boxes, and online platforms, to collect timely opinions and suggestions, and adjust teaching strategies accordingly. After each teaching activity, teachers should promptly provide students with feedback, highlighting their strengths and areas for improvement, and offering constructive suggestions.

Teaching supervision: Arrange for teaching supervisors to regularly visit classrooms to monitor teaching quality and student learning, providing improvement suggestions. Write teaching quality reports each semester to summarize issues and improvement measures, ensuring a steady enhancement of teaching quality.

By implementing these internal quality control measures, the school can effectively ensure that the cultural study courses meet high standards and continuously improve over time.

3.2. External quality audit

External quality audit refers to the evaluation of courses by external experts, industry representatives, or third-party assessment institutions to ensure the quality and credibility of the courses.

Expert review: Invite scholars and experts in the field of culture to review the course content and teaching activities, providing professional opinions and suggestions. Collaborate with relevant industry associations to obtain their recognition and certification of the course, enhancing its professionalism and authority.

Third-party assessment: Entrust independent third-party assessment institutions to conduct a

comprehensive evaluation of the course, covering aspects such as student learning outcomes, teacher teaching quality, and teaching resources, ensuring the objectivity and fairness of the assessment.

Social oversight: Invite parents and members of the public to participate in the evaluation and supervision of the course, gathering their opinions and suggestions to increase societal recognition and support for the course.

By implementing these external quality audit measures, the institution can ensure that the cultural study courses meet high standards and gain widespread trust and endorsement from both professionals and the public.

3.3. Continuous improvement measures

Continuous improvement refers to the ongoing optimization of course design and implementation strategies based on evaluation results and feedback, ensuring the continuous enhancement of course quality.

Adjusting teaching content: Based on student feedback and data analysis, adjust the teaching content by adding or removing certain modules to ensure its relevance and practicality. Additionally, integrate knowledge from other disciplines such as history, art, and technology to enrich the course content and enhance students' overall competence.

Optimizing teaching methods: Incorporate more interactive, experiential, and project-based learning methods that align with students' learning styles and interests, increasing their motivation and participation. Provide personalized guidance and support tailored to different students' learning abilities and needs, helping them better acquire knowledge and skills.

Improving assessment standards: Based on evaluation results, refine and improve assessment standards to ensure they are scientific and reasonable, accurately reflecting students' learning outcomes. Adopt a variety of assessment methods, such as exams, projects, reports, and presentations, to accommodate different learning styles and strengths.

Enhancing technical support: Introduce modern educational technologies like virtual reality and online learning platforms to diversify teaching methods and enhance teaching effectiveness. Form a technical support team to provide timely assistance to both teachers and students, ensuring the smooth operation of teaching activities.

Refining feedback mechanisms: Further improve the student feedback mechanism to ensure that students' opinions and suggestions are promptly communicated to teachers and administrators, promoting continuous course improvement. Conduct a course review at the end of each semester to summarize experiences and lessons learned, and propose specific improvement suggestions to ensure the continuous enhancement of course quality.

By implementing these continuous improvement measures, the institution can ensure that the cultural study courses remain up-to-date, effective, and responsive to the evolving needs of students and the broader educational landscape.

4. Conclusion and future prospects

This study, based on the AOL system, explores key measures for the design, implementation, evaluation, and continuous improvement of cultural study courses. In terms of course design, the study proposes setting multi-dimensional and measurable objectives, selecting appropriate teaching content, conducting diverse teaching activities, and establishing a robust assessment and feedback mechanism to support students' learning and

development. For course implementation, using the cultural study courses at Shanghai Zhongqiao University of Technology and Vocational Education as a case study, the research ensures the smooth progression of the course through four critical phases: preparatory work before implementation, monitoring and feedback during implementation, evaluation and reflection after implementation, and exhibition and promotion of outcomes. In ensuring quality and continuous enhancement, the study employs both internal and external quality control measures, along with ongoing optimization of course design and implementation strategies, to maintain the credibility of the courses and continuously improve their quality.

This research enriches the application theory of the AOL system in vocational education, offering new perspectives and methods for the design and implementation of cultural study courses. It provides valuable references for related course construction in other vocational institutions. Looking forward, further research could explore the integration of the AOL system with other educational theories, such as constructivism and situated learning theory, to develop more diverse teaching methods and assessment criteria. Additionally, the promotion of AOL-based cultural study courses to more vocational institutions can help explore their effectiveness across different majors and grade levels. Given the rapid development of artificial intelligence, investigating how modern technological tools can be integrated into cultural study courses to enhance teaching effectiveness and student learning experiences is also of significant importance. By advancing these areas, the study aims to contribute to the broader field of vocational education, promoting innovative and effective practices that benefit both educators and learners.

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Analysis of Key Success Factors in Cultural and Artistic Management and Educational Model Innovation

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Abstract: In the context of globalization and digitalization, cultural and artistic management and educational model innovation have become the core driving force for the sustainable development of the industry. This article systematically sorts out the six key success factors of strategic planning, content innovation, organizational change, user orientation, and dynamic evaluation through case analysis and theoretical discussion. These factors work together to provide a clear path and impetus for the sustainable development of the cultural and arts industry.

Keywords: Cultural and arts management; Educational model innovation; Key success factors

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1. Introduction

Today, as digital technology reshapes society, the cultural and art industry and the education sector face challenges such as low efficiency of traditional models, scattered resources, and diversified user needs. How to break through bottlenecks through innovation has become a topic of common concern in academia and industry. This article combines typical cases such as a city's "One Person, One Art" art popularization project, a film and television IP strategy, and an AI education assistant to analyze the factors for successful innovation from multiple dimensions and provide a practical path for reference for the industry.

2. Strategic planning: Synergy between policy orientation and resource integration

Strategic planning is the core driver of innovation in cultural and artistic management and education models. Its success depends on the top-level design guided by policies and the systematic layout of resource integration. At the policy level, the "One Person, One Art" national popularization project incorporates art popularization into the public cultural service system through the government-led "4+2" content system, forming an ecological

model of “government setting the stage, social participation, and national sharing”^[1]. The project not only received an average of 4.5 million yuan in special financial support per year, but also clarified the responsible entities and assessment mechanisms through the “Regulations on Public Cultural Service Guarantee of a Certain City” to ensure the sustainability of policy implementation. As of 2020, the number of registered users reached 650,000, with an overall participation rate of over 80%, becoming a benchmark case for public cultural service innovation across the country. The Ministry of Education’s “Education Digitalization Strategy” also promotes AI, big data, and other technologies to empower new education tracks through policy guidance. For example, the “Education Informatization 2.0 Action Plan” proposes the “three comprehensive, two high, and one large” goals, clarifies the path and standards for the integration of educational technology, and provides institutional guarantees for industry innovation^[2].

In terms of resource integration, cross-domain collaboration is the key to breaking through the dilemma of decentralized resources. The “Cultural Gas Station” project in Beilun District of a certain city integrates the resources of 344 institutions, such as cultural centers, communities, and enterprises, through the “1+N” digital service platform to form a “menu-style” service architecture. The platform adopts the “online appointment + offline experience” model, serving more than 100,000 people per year, and increasing resource utilization by 40%. In the field of education, a certain university has jointly developed the “Zhi Hai” intelligent education model with Alibaba, SenseTime, and other companies to build an industry-university-research collaborative innovation network. Through the “data sharing + joint research and development” mechanism, the platform deeply integrates the academic resources of universities with the technical capabilities of enterprises, and has incubated 12 innovative achievements such as AI teaching assistants and virtual laboratories, covering more than 200 universities across the country. In addition, the synergy between policies and resources needs to be optimized through a dynamic feedback mechanism^[3].

3. Technology empowerment: Efficiency and model reconstruction driven by digitalization

AI and big data technologies promote the transformation of services from “standardization” to “personalization” by accurately analyzing user needs. The “One Person, One Art” cloud platform in a certain city mentioned above uses user portrait technology to integrate registration information, course click-through rate, completion rate, and other data to build a “multi-dimensional label system” and recommend adaptive courses through collaborative filtering algorithms^[4]. For example, the “Introduction to Animation Art” course is pushed to young users, and the “Appreciation of Traditional Opera” is recommended to middle-aged and elderly users, which increases the course matching degree by 35% and covers more than 500,000 users. The “Xiaohang” AI assistant of a certain university provides integrated support for “learning, research, and management” for teachers and students through natural language processing technology. In the learning scenario, it can answer subject questions and recommend knowledge graphs; in the scientific research scenario, it integrates literature data and data analysis tools to assist in paper writing; in the management scenario, it automates the processing of homework grading, attendance statistics, and other matters, and improves the work efficiency of teachers by 40%^[5].

Technologies such as virtual reality (VR) and augmented reality (AR) break the limitations of time and space and reconstruct cultural and educational scenarios^[6]. For example, the “Digital Cultural Relics Restoration” project of the Palace Museum simulates the restoration process of cultural relics through VR

equipment. Users can “touch” virtual cultural relics and learn traditional skills. After the project was launched, the number of visits exceeded 2 million. In the field of education, a university’s “Metaverse Classroom” uses AR technology to visualize abstract concepts, such as converting quantum mechanics wave functions into three-dimensional dynamic models, which improves students’ understanding efficiency by 60%. In addition, AI-generated content technology promotes the democratization of artistic creation, such as the “AI Composition Assistant” developed by the Shanghai Symphony Orchestra. Users can generate customized melodies by entering emotional keywords, lowering the threshold for creation and stimulating the enthusiasm of the public to participate in art ^[7].

4. Content innovation: Interdisciplinary integration and value transformation

Interdisciplinary education cultivates compound talents by breaking down disciplinary barriers. The “10+35” model of a middle school integrates subject knowledge such as Chinese, history, and science into project-based learning ^[8]. For example, in the “Yellow River Ecological Governance” project, students need to analyze basin characteristics based on geographical knowledge, interpret governance policies based on historical background, evaluate ecological impacts based on biological subjects, and propose solutions through data analysis. This model improves students’ critical thinking ability by 25% and their ability to apply interdisciplinary knowledge by 40%. The field of educational technology also integrates online resources and offline interactions through “hybrid teaching.” The “smart classroom” system of a university integrates MOOC courses, virtual simulation experiments, and classroom discussions. Students can learn basic theories online and simulate chemical reactions or historical scenes offline through VR, realizing the closed loop of “knowledge input-practice verification-reflection optimization.” In the cultural field, a city’s “art popularization + rural construction” project deeply integrates art popularization with rural revitalization to create an “art empowers rural areas” model.

The transformation of cultural values needs to be based on traditional elements and to achieve national expression through modern narratives. The “super IP strategy” of a certain film and television company has promoted works such as “The Rise of Phoenixes” to the international market through the three-step method of “cultural decoding-creative reconstruction-global communication.” For example, the drama is based on Tang Dynasty costumes and etiquette, and incorporates suspenseful plots and visual aesthetics. It has been broadcast overseas more than 500 million times, and its derivative sales have reached 200 million yuan. In the field of education, cultural identity is strengthened by “intangible cultural heritage in the classroom.” For example, a middle school has developed a “Wu Culture Course Package” to integrate intangible cultural heritage skills such as Suzhou embroidery and Pingtan into aesthetics and Chinese teaching. Students can achieve the integrated inheritance of “knowledge-emotion-action” by making Suzhou embroidery bookmarks and writing Pingtan stories. In addition, value transformation needs to be combined with technology to achieve scene reconstruction. The “Digital Cultural Relics Library” of the Palace Museum has transformed “A Thousand Miles of Rivers and Mountains” into a dynamic digital volume through 3D modeling and interactive design. Users can “walk into” the painting to experience the landscape of the Song Dynasty. The number of visits to the project exceeded 100 million after it was launched ^[9].

5. Organizational change: Flexible mechanisms and open ecosystems

Traditional bureaucratic systems are difficult to adapt to the needs of rapid iteration. In the enterprise field,

Giant Network reconstructed its organizational structure through the “modular division of labor + dynamic collaboration” mechanism. It split the R&D team into “small front-end” groups of 15–20 people, each focusing on the development of a single product function, and set up a “middle-end” to share technical resources and data support, while the back-end is responsible for strategic coordination and risk control. This model shortens the project iteration cycle by 30%, and the user retention rate of the “Zhengtu” series of games has increased to 65%. The “One Person, One Art” social alliance in a certain city has absorbed 344 cultural institutions, enterprises, and social organizations through the “government-led + institutional collaboration” mechanism, forming a “demand docking-resource integration-effect evaluation” closed loop. For example, the community art festival matches the dancers’ association, enterprises, and school activities through the alliance platform. The preparation time is compressed from 3 months to 15 days. In the field of education, the “271” teaching model of a middle school releases students’ subjectivity through the reconstruction of classroom structure. Teachers only spend 20% of their time explaining knowledge points, 70% of their time guiding students to explore in groups, and 10% of their time on personalized tutoring. This model breaks the traditional “cramming” teaching method, and the student participation rate has increased from 45% to 82%. The college entrance examination key rate has increased for 10 consecutive years. A certain No. 3 middle school has further implemented the “project-based grade group,” which consists of a fixed team of interdisciplinary teachers to jointly design thematic courses such as “garbage classification” and “urban traffic optimization,” and the teacher’s writing efficiency has increased by 50% ^[10].

An open ecosystem is the guarantee for the sustainable development of innovation. In knowledge sharing, Harvard University’s “Open Educational Resources” project breaks down regional barriers and promotes global knowledge sharing. For example, its “Calculus” online course has attracted a total of 1.2 million learners and has spawned collaborative teaching projects at 15 universities around the world. In the field of art, the “Crowd Innovation Space” brings together designers, technical teams, and market experts to accelerate the transformation of results. For example, a team of digital artists worked with an AR company to develop the “Virtual Dunhuang” exhibition, which took three months from concept to implementation and attracted more than 50,000 tourists. In addition, in the field of education, a local “Future School Laboratory” has joined forces with universities and scientific research companies to develop AI teaching tools, such as the “Intelligent Composition Correction System,” which has covered 200 schools and increased teacher correction efficiency by 70% ^[11].

6. User-oriented: Demand insight and value co-creation

User demand is the core driving force of innovation, and its identification and satisfaction need to rely on data intelligence and scenario-based design. In the field of tourism, a city’s tourism platform achieves precise service supply through “multi-source data fusion + behavior modeling,” integrating 10 types of data sources such as OTA reservation data, scenic spot Wi-Fi positioning, and social media comments to build a tourist preference map. The platform uses machine learning algorithms to identify segmented needs, such as parent-child travel and silver-haired travel, and dynamically adjusts recommendation strategies. In 2023, the user complaint rate will drop by 42%, and market satisfaction will increase by 7.05%. In the field of education, the “Zhi Hai Personalized Learning Platform” diagnoses students’ weak links through knowledge graphs, generates a combination of “micro-class video + wrong question analysis + interactive exercises,” and dynamically adjusts the difficulty based on learning time, accuracy, and other data, so that students’ scores improve by an average of 25%. Such practices show that data-driven precision services need to take into account both technical depth

and scenario adaptation, and maximize user value through the closed loop of “demand identification-path generation-effect iteration.”

Deep user participation can strengthen value recognition and promote service innovation and cultural heritage. The Palace Museum’s “Digital Cultural Relics Restoration” project achieves value transformation through the “public participation-professional guidance-results sharing” model. Its users simulate the steps of splicing and coloring cultural relics through the app. Experts comment online and select high-quality solutions for reference in physical restoration, and make excellent works into digital collections to provide feedback on cultural relics protection. After the project was launched, the number of public participants reached 8 million, and the degree of cultural dissemination increased by 3 times ^[12]. In the field of education, a school’s “project-based learning” allows students to lead the design of topics. For example, the “community elderly care plan” project was led by students to survey needs and connect resources, and the final plan was adopted and implemented by the government. This model has improved students’ problem-solving ability by 40% and their social service awareness by 65%. The essence of user co-creation is to build “demand expression-cooperative design-value sharing” and achieve two-way empowerment of individual creativity and organizational goals through technical empowerment and mechanism incentives.

7. Evaluation and iteration: Dynamic optimization and risk management

The improvement of innovation efficiency depends on scientific evaluation and a dynamic iteration mechanism. The “One Person, One Art” social alliance of a certain city verified the effectiveness of the project through the dual-track evaluation system of “third-party evaluation + user feedback.” It commissioned a university team to quantify 12 indicators such as participation rate, satisfaction, and cultural popularity, and established an “opinion wall + online questionnaire” to collect citizen suggestions. Data shows that in the three years since the implementation of the project, the citizen art participation rate has increased from 15% to 43%, and the satisfaction rate has reached 92%. In the field of education, a full-cycle evaluation model is constructed by combining “process evaluation + result evaluation.” For example, the second middle school of a certain city adopts the three-dimensional indicators of “classroom performance data + project results + peer evaluation” to dynamically adjust the “271” teaching model. A district introduced a “learning analysis system” to warn of learning risks through data such as homework completion rate and knowledge point mastery curve. After teacher intervention, the student pass rate increased by 28%. Such practices show that evaluation needs to take into account both quantitative indicators and qualitative feedback, and achieve continuous improvement through the closed loop of “data collection-effect analysis-strategy adjustment.”

Innovation needs to balance efficiency and risk, and technological ethics and cultural adaptation are key considerations. In the field of AI applications, algorithmic bias may exacerbate social injustice. For example, an AI art creation platform has a low recognition rate of 35% for oriental-style works because its training data is biased towards Western painting styles. Later, by introducing a “Cultural Fairness Review Committee” to optimize the dataset, the recognition accuracy rate increased to 89%. Over-reliance on technical tools in educational innovation should be taken into consideration. For example, AI art creation needs to avoid algorithmic bias, and educational innovation needs to prevent the instrumentalization of technology from weakening humanistic care. A school once caused student anxiety due to the “AI proctoring system,” and later added a “psychological assessment module” and allowed 20% of courses to return to traditional teaching, and the student stress index dropped by 40%.

8. Conclusion

Cultural and artistic management and educational model innovation are systematic projects that require coordination in multiple dimensions, including policy, technology, content, organization, users, and evaluation. In the future, we need to further explore the application of generative AI in content and teaching, build an immersive experience that combines virtuality and reality, and promote cross-cultural dialogue and international expression based on local culture. Only in this way can we achieve two-way empowerment of social and economic benefits and inject lasting impetus into the construction of a cultural power.

Disclosure statement

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Research on Risk Indicators of Project Procurement in Higher Education Institutions

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Abstract: This paper focuses on the procurement of construction projects in universities, conducting research on the influencing factors of procurement risks in such projects. By combining questionnaire surveys with expert interviews, numerous factors affecting procurement are analyzed. Subsequently, these factors are refined and summarized to construct a procurement risk evaluation index system for construction projects, which includes three first-level indicators, such as process management risk and ethical/legal risk, and is further subdivided into 13 second-level indicators.

Keywords: Risk evaluation indicators; Project procurement; University construction projects; Procurement management

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1. Introduction

With the accelerated advancement of the country's modernization process, major infrastructure construction is booming nationwide on an unprecedented scale. As lifeline projects underpinning economic and social development, their quality not only concerns the safety of people's lives and property but also serves as a strategic cornerstone for achieving long-term stability and sustainable development of the nation. Against the backdrop of the continuous emergence of iconic projects such as super high-rise buildings, cross-sea bridges, and smart city clusters, the complexity of engineering systems has increased exponentially. The application of innovative technologies such as ultra-deep foundation treatment, large-span spatial structures, and intelligent construction techniques poses unprecedented challenges to the management of the entire construction process. It is noteworthy that in the pursuit of construction speed and technological innovation, quality control risks have multiplied in multiple dimensions. An analysis of typical cases in the engineering field in recent years reveals that approximately 68% of the root causes of major quality accidents can be traced back to the loss of control in the material procurement phase ^[1]. Faced with the complexities of engineering construction in the new era, it is urgent to establish a comprehensive risk prevention and control system. As the first line of defense

for engineering quality control, procurement management shoulders the strategic mission of source control. By establishing and improving a compliant procurement mechanism, not only can the influx of substandard building materials onto construction sites be blocked at the source, but also a “prevention-monitoring-emergency response” trinity quality firewall can be constructed through measures such as standardizing the bidding process, strengthening supplier qualification reviews, and implementing full-lifecycle quality traceability^[2].

2. Identification of procurement risk evaluation indicators

By extensively reviewing relevant references^[3–17] on procurement in university construction projects, the factors influencing procurement risks in such projects were summarized and distilled to form an initial list of risk factors through keyword-based data filtering. Questionnaires were distributed anonymously to relevant experts via QQ and face-to-face interviews to screen the original indicators, remove those of low frequency, and optimize the original risk list. Key factors affecting procurement risks were identified to refine other factors.

3. Indicator screening

The cost of procurement activities accounts for a significant proportion of the total project investment, making their importance self-evident. The quality of procured products and their delivery on time will determine or influence the quality and completion time of the project, potentially even doubling the overall project cost. Scientific project procurement management, employing modern analytical methods, optimizes the procurement management process, ensuring project quality within controllable construction costs and advancing project progress as planned, which is the inevitable choice for high-quality procurement management. Project procurement is a complex activity susceptible to various uncertainties. Thoroughly analyzing and distilling potential risks, based on the characteristics of procurement risks, questionnaires were conducted via modern means such as QQ and WeChat to consult with experts in the engineering construction field, staff from relevant research institutes, and engineering construction companies. Procurement risk data were collected and analyzed to form preliminary risk evaluation indicators, which were further refined by combining research findings from relevant references to optimize the risk evaluation indicators.

4. Indicator system

The procurement risk indicator system for university construction projects constructed in this paper consists of three first-level risk indicators and 13 second-level risk indicators. Specifically, the process management risk, ethical and legal risk, and external and decision-making risk are the three first-level risk indicators. Process management risk includes improper process risk, demand change risk, delay in publicizing review results risk, and approval delay risk. Ethical and legal risk includes supplier non-compliance with qualification risk, improper agency behavior risk, improper on-campus procurement management risk, and improper bid evaluation standard risk. External and decision-making risk includes data leakage risk, decision-making error risk, policy and market risk, and fund disbursement risk.

4.1. Process management risk

4.1.1. Improper process risk

Not following the procurement process stipulated by the competent authority or not adhering to relevant laws

and regulations on project procurement bidding, tendering, and bid evaluation, such as collusive bidding or private arrangements, leads to unfair competition, potentially causing resource waste and even affecting the quality and schedule of the construction project. Therefore, the procurement process must be scientific, reasonable, legal, and compliant.

4.1.2. Demand change risk

Market developments, changes in educational philosophy, advancements in engineering construction technology, and changes in enrollment scale can all cause changes in established client demands. Procurement projects already initiated may not meet new demands, leading to secondary or even tertiary procurements, skyrocketing procurement costs, and severe resource waste. Before substantial project procurement activities, universities must convene professionals to conduct in-depth and extensive demand analysis, gain a deep understanding of the school's long-term development plans, and formulate scientific procurement plans for construction projects to avoid potential risks arising from demand changes.

4.1.3. Delay in publicizing review results risk

Due to improper transactions, reluctance of relevant parties to bear legal liabilities for potential risks, etc., there may be delays in publicizing review results. In severe cases, this will affect the progress of construction projects, extend the construction period, and increase construction costs. Universities must strictly follow the process to publicize procurement review results, ensuring fairness and justice to advance procurement work with high quality.

4.1.4. Approval delay risk

Multiple project management departments, inadequate staffing, complex approval processes, cumbersome procedures, poor technical skills of office staff, incomplete procurement plans, or hidden errors in documents will lead to delays in approving procurement review results, or even delays in the entire project, increasing construction costs.

4.2. Ethical and legal risk

4.2.1. Improper bid evaluation standard risk

Problems with bid evaluation standards themselves, non-compliance by bid evaluation experts with established standards, improper transactions between bid evaluation experts, participants, and tenderers, or conceptual deviations among bid evaluation experts and participants will make bid evaluation standards improper, affecting the fairness and justice of bid evaluation results, the quality of procured engineering materials, and even the quality of engineering construction. In summary, universities must supervise bidding, tendering, and bid evaluation links adequately and severely crack down on any improper behavior affecting these links.

4.2.2. Improper on-campus procurement management risk

Due to the continuous expansion of university scale, numerous management departments, cluttered management, and disordered conditions, different departments have varying needs for construction projects, with a lack of communication between departments and repeated construction phenomena, leading to repeated procurements and resource waste. Universities need to establish a comprehensive procurement management mechanism, ensuring effective monitoring and punishment, standardized and transparent procurement processes, smooth communication between departments, and real-time review of procurement processes to promptly

correct deviations and trace the source to eliminate hidden dangers arising from improper management.

4.2.3. Improper agency behavior risk

Risks arising from exceeding authority, abusing power, violating integrity principles, or failing to fulfill reasonable duty of care in the procurement process of construction projects will undermine the fairness and justice of project procurement and affect the interests of relevant parties in the project. Universities need to conduct strict assessments of integrity and professional ethics aspects to select agencies, clarify agency authority, strengthen agent supervision, improve contract terms, and enhance legal awareness to prevent risks.

4.2.4. Supplier non-compliance with qualification risk

Suppliers not possessing statutory or agreed-upon qualification conditions lead to invalid contracts, insufficient performance capabilities, product quality defects, and difficulties in meeting universities' strict engineering construction quality standards. This risk has a significant impact and occurs frequently in actual engineering construction, affecting construction quality and even causing serious safety issues. Universities need to prevent risks through standardized reviews, dynamic checks, and contractual constraints, and take timely legal remedial measures when qualification issues are discovered to avoid expanding losses.

4.3. External and decision-making risk

4.3.1. Decision-making error risk

In university construction project procurement, during the procurement of equipment, materials, etc., due to insufficient information, improper selection, execution deviations, or changes in the external environment, decision-making errors lead to procurement results failing to meet project needs, causing increased costs, inefficient use of resources, project delays, quality defects, and even legal disputes. Such risks pervade the entire procurement process and require prevention and control through systematic management. Universities must establish a scientific decision-making system, use digital procurement platforms to achieve transparent management of the entire process, entrust professional procurement agencies, adopt expert opinions, ensure every procurement decision is well-considered, enhance decision-making scientificity, and avoid unnecessary economic losses.

4.3.2. Data leakage risk

Currently, with the rapid development of information technology, various departments in universities have strengthened information management. Technical vulnerabilities, management defects, and human errors in on-campus information facilities may lead to sensitive data leakage during construction project procurement, or attackers may exploit procurement processes to breach information security defenses, potentially causing leakage of important school data such as academic achievements, financial information, and student grades, or leakage of teachers' and students' personal privacy, which may lead to legal liabilities, reputation damage, and academic misconduct. Universities need to introduce data security governance platforms or entrust professional security agencies for regular assessments and reinforcements. A rigorous data protection mechanism should be established to construct a defense system from multiple dimensions of technology, management, and law.

4.3.3. Fund disbursement risk

During the execution of university construction projects, multiple links from the disbursers to contractors or suppliers may trigger risks due to management, operational, or external factors. Universities need to prevent

and control risks through multiple dimensions of systems, contracts, technology, and personnel. The key lies in establishing a full-process, full-element risk management system to ensure safe, compliant, and efficient fund circulation.

4.3.4. Policy and market risk

During the promotion of university construction projects, policy adjustments by national or local governments directly affect project compliance, financing capabilities, and market demand. Uncertainties in the market environment, such as demand fluctuations, increased competition, and price changes, directly affect project procurement costs. Universities need to establish a policy dynamic monitoring mechanism to assess the impact of policy changes on projects in advance, strengthen legal compliance reviews in the early stages of projects to ensure compliance with current policy requirements, and set policy adjustment clauses in contracts to clarify risk-sharing mechanisms. Meanwhile, through tools such as big data analysis and industry reports, accurately grasp market trends; adopt centralized procurement and long-term contracts to lock in prices, reducing the risks of fluctuations in raw material costs.

Disclosure statement

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Exploration of Curriculum Reform Based on ADDIO2OE Blended Teaching Model

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Abstract: Blended learning is an important practice of teaching reform in universities, which effectively integrates online and offline teaching resources. Through the participation of teachers in the learning process and helping students construct knowledge, the teaching philosophy of “learning as the center” is realized, which plays an important role in improving the quality of teaching courses and cultivating professional talents. This article analyzes the problems in course teaching, proposes a hybrid teaching design strategy based on the ADDIO2OE model, analyzes the specific requirements of each stage, and conducts research and discussion to form a complete teaching model, aiming to deepen teaching reform and improve teaching quality.

Keywords: Blended learning; ADDIO2OE model; Course design; Teaching reform

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1. Introduction

The development of information technology has driven the pace of curriculum and teaching reform in universities, as well as promoted changes in the teaching mode of in-service courses. The blended learning model is usually guided by constructivist learning theory and behaviorism, and utilizes modern information education technology and platforms to integrate and optimize teaching resources, achieving complementary advantages between classroom teaching and online learning. Blended learning breaks through the limitations of traditional teaching space and time, redefining the subject position of students in learning. Teachers fully play a guiding and supervisory role, thereby mobilizing the enthusiasm and initiative of students in learning. Integrating online learning into the teaching process allows students to engage in self-directed learning according to their individual needs and time arrangements ^[1].

2. ADDIO2OE teaching design model

A systematic instructional design model is an abstract graphical description of instructional design theory and a

guiding model for curriculum design and development. The course is based on talent cultivation goals and the ADDIE model, combined with the concept of “O2O” proposed by Professor Alex Rampell of the United States, and innovatively proposes the “ADDIO2OE” blended teaching model (as shown in **Figure 1**), fully reflecting the “student-centered” teaching philosophy^[2-4].

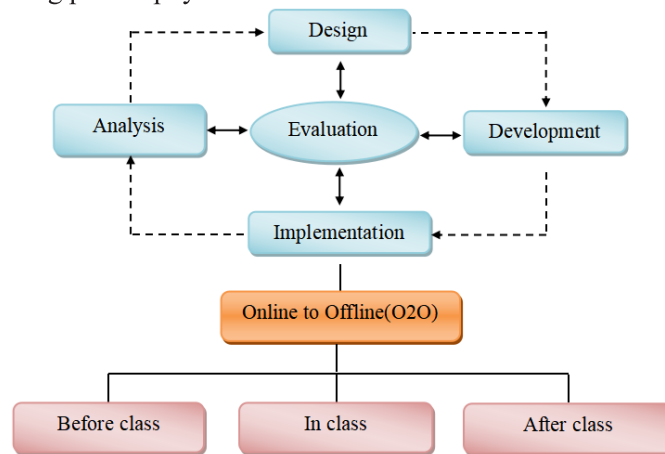


Figure 1. “ADDIO2OE” teaching model

3. Scientific construction of a blended teaching model for curriculum

The ADDIO2OE blended learning model embodies the core and common characteristics of the instructional design theory model. The instructional design process is divided into five stages: analysis, design, development, implementation, and evaluation^[5-8], as shown in **Figure 2**. The following is a detailed explanation of the instructional design model.

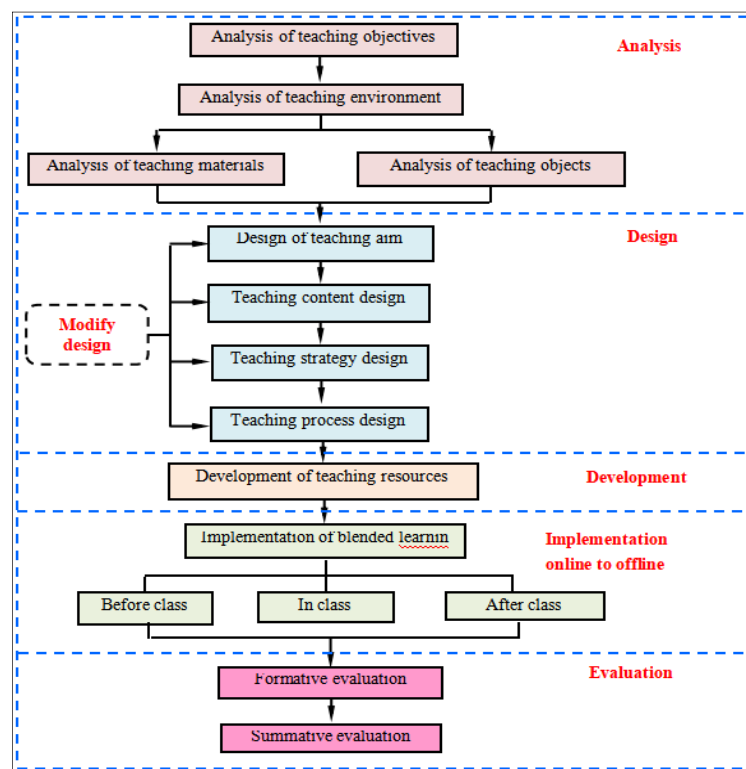


Figure 2. ADDIO2OE blended learning model

3.1. Analysis stage

Analysis is a prerequisite for smooth teaching practice. The analysis stage runs through the entire process of course teaching, mainly analyzing teaching objectives, learning objects, and teaching environment. The analysis stage, as the primary component of the ADDIO2OE model, plays an important role in the subsequent teaching work. In the analysis of teaching objectives and learning objects, teachers should rely on the curriculum design in the talent training program to match the professional teaching needs of students, and complete the overall teaching objectives on the basis of ensuring personalized teaching for students. In the analysis of the teaching environment, attention should be paid to the integration of classroom teaching and online learning modes, which not only stimulates the enthusiasm of students for online learning but also achieves the effect of offline classroom teaching.

3.2. Design stage

During the design stage, teaching objectives and content were designed based on the above analysis of the learning situation. As a professional export course to cultivate aviation material storage personnel, students need to achieve knowledge, abilities, and ideological and political goals through learning. Guided by the new teaching reform concept of “focusing on employment, focusing on actual combat, and focusing on shipboard,” and based on the design idea of “going from simple to deep,” the course content is constructed according to the “backward method,” the typical work tasks are determined, the corresponding business capabilities are sorted out, and three knowledge modules are constructed. The second module, “aviation materials warehouse equipment management,” covers the key and difficult contents of the course, mainly including warehouse equipment management, storage and transportation operation processes, and different warehouse operation methods and requirements in each link. Through learning, the storage management ability of students is improved, laying the foundation for achieving the talent training goal.

3.3. Development stage

Based on the analysis of course construction goals and content design, we have entered the development stage. The main tasks of this stage are to collect teaching materials, publish basic textbooks, and develop and select auxiliary teaching resources. Firstly, following the concept of “position-driven and ability-driven,” we have completed the construction of “three-dimensional” textbooks and have successively published academic monograph-style textbooks, smart textbooks, and practical teaching guidance books. Secondly, following the concept of “shore ship integration and information fusion,” a “multifunctional” laboratory group has been established, such as the Aviation Materials Professional Smart Classroom and Aviation Materials Storage Training Center, which can support the development of multiple practical teaching courses in this course. Finally, following the concept of “co-construction and sharing, diverse forms,” a “series” of digital resources have been developed, including high-quality MOOC and micro courses, supporting SPOC courses, etc., providing strong support for the reform of the curriculum teaching mode.

3.4. Implementation stage

Before class, a notice will be posted on the teaching platform for students to preview and complete the pre-class self-test through the guidance task sheet. In class, the course is taught in a smart classroom. Students are divided into groups to report the pre-class preview content, guide discussions and exchanges, and the teacher explains the key and difficult points through theoretical explanations, multimedia courseware, and practical teaching, promoting the understanding and digestion of knowledge. After class, the instructor supervises the students to

complete their homework and actively guides them to fill in any gaps, participate in online discussions, and promote the improvement of their job skills^[9,10].

During the implementation stage of the curriculum, ideological and political education should always be integrated throughout the entire teaching process. Teachers can share a micro video on the spirit of craftsmanship before class to cultivate the professional ethics of soldiers who fulfill their duties and responsibilities. Combining teaching cases and typical characters with ideological and political elements in class, students' rigorous and meticulous work style is cultivated. After class, a mind map is drawn to stimulate students' creative thinking.

3.5. Evaluation stage

The evaluation stage includes both the evaluation of the learning effectiveness of the students and the evaluation of the course and implementation effectiveness, including formative evaluation and summative evaluation.

Formative evaluation runs through various stages of blended learning, focusing on examining the completion of learning tasks by students, as well as the comprehensive analysis and cultivation of practical application abilities. It comprehensively evaluates students from multiple perspectives. The summative evaluation is conducted after the completion of teaching implementation, mainly focusing on the comprehensive assessment and evaluation of students' learning effectiveness, knowledge mastery, and ability development. Teachers summarize and reflect on the evaluation results, correct the pre-steps of teaching design, and form a practice of blended teaching design through iterative cycles^[11].

4. Conclusion

The blended teaching design of in-service courses based on the ADDIO2OE teaching model is a new teaching attempt. The model has strong step-by-step operability and introspective cycle characteristics. The five stages work together to form a closed loop, integrating the advantages of traditional lecture-based teaching and online teaching. It helps to transform the teaching philosophy of teachers and innovate classroom teaching modes, greatly mobilize the learning enthusiasm of students, cultivate their job skills, and improve the quality of course teaching.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Advantages, Shortcomings, and Countermeasures of Current Higher TCM Education

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Abstract: Traditional Chinese Medicine (TCM) is a treasure of China's traditional medical heritage, embodying the wisdom and cultural depth of the Chinese nation. Higher TCM education shoulders the important responsibility of preserving and advancing TCM, and in today's context, it offers significant advantages while also facing numerous challenges. Among its strengths are a profound cultural foundation in TCM, utilizing classic texts and unique theories to cultivate students' TCM thinking and competence; diversified teaching methods that integrate knowledge from multiple disciplines, innovate instructional models, and combine traditional with modern educational approaches; a complete teaching system characterized by professional faculty and advanced facilities; and interdisciplinary integration fostering innovation. However, problems persist, including some students lacking confidence in TCM culture due to the influence of Western medicine concepts and the westernization of the educational model; weak practical teaching where theory dominates, practice time is limited, and there are insufficient bases and instructors; and a shortage of faculty resulting in an imbalanced student-to-teacher ratio and an unreasonable structure. To address these issues, it is recommended to enhance cultural confidence, strengthen faculty development, and optimize practical teaching, thereby promoting the sustainable development of higher TCM education and achieving the shared prosperity of TCM education and the TCM profession.

Keywords: Higher TCM education; Advantages; Shortcomings; Strategies; Research

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1. Introduction

Traditional Chinese Medicine (TCM), known as the “art of Qi and Huang,” is a treasured part of China's traditional medical heritage, embodying the wisdom and cultural depth of the Chinese nation. It has been a crucial factor in sustaining Chinese civilization for thousands of years. At its core, TCM seeks harmony

between nature and humanity, representing the process by which human intellect confronts illness and strives to find optimal solutions for health ^[1]. Over time, TCM has developed a theoretical system grounded in concepts like yin-yang and the five elements, characterized by holistic views and differentiated treatment approaches. As an original medical science of the Chinese nation, it has significantly contributed to the prosperity of the Chinese people. Higher education in TCM shoulders the responsibility of preserving and advancing this tradition. With societal progress and improvements in educational systems, TCM teaching has grown stronger, with increasingly refined faculty teams. In recent years, higher TCM education has achieved notable successes. Simultaneously, it faces new opportunities and challenges. Under current circumstances, thoroughly examining the strengths and weaknesses of higher TCM education and proposing corresponding strategies is of great practical significance for enhancing educational quality, cultivating outstanding TCM practitioners, and preserving and developing TCM culture.

2. Current status of higher TCM education

With the continuous refinement of educational philosophies, higher TCM education has significantly improved upon traditional models. The number of students has increased, but employment rates remain much lower than those of Western medical school graduates, largely due to practical conditions. In many TCM institutions, Western medicine courses occupy a substantial portion of the curriculum. The increasing influence of Western medicine can lead to gaps in TCM knowledge, leaving students with an insufficient understanding of both systems. This results in graduates entering clinical settings with weaker clinical and emergency response capabilities, making it harder for them to contribute effectively to hospitals. Compared to their peers from Western medical schools, the gap is significant, leading TCM graduates to spend considerable time catching up on Western medical courses while their Western-trained counterparts focus on specialized development. Hospitals, aiming for maximum benefit, often favor graduates from Western medical programs. The primary reason for this disparity lies in the lack of targeted education during schooling, which fails to adapt to modern needs while focusing too narrowly on TCM development. Faculty teams are limited to guiding specific courses, hindering not only TCM students but also wasting valuable resources within the TCM field ^[2].

3. Current advantages of higher TCM education

3.1. Rich TCM cultural heritage

TCM boasts a long history, having accumulated a rich theoretical system and clinical experience over millennia. Higher TCM education leverages this profound heritage, providing systematic learning of TCM knowledge. Students study ancient classics such as the *Huangdi Neijing*, *Shanghan Zabing Lun*, and *Shennong Bencaojing*, gaining insight into the depth of TCM theory. These works contain core ideas like holism, differentiated treatment, and yin-yang and five-element theories, offering important foundations for understanding TCM principles and clinical practice. With its unique theoretical framework, TCM stands distinctively in global medicine. Holism emphasizes the body as an organic whole interconnected with natural and social environments. Differentiated treatment involves analyzing symptoms, signs, tongue appearance, and pulse characteristics to determine diagnostic patterns and develop personalized treatments. In higher TCM education, students systematically learn TCM theory to grasp its thinking and diagnostic methods, laying a solid foundation for future clinical work. For instance, in TCM diagnostics, students learn to collect patient information through observation, auscultation, inquiry, and palpation, then analyze and diagnose using differentiated treatment.

TCM offers diverse therapeutic methods, including herbal medicine, acupuncture, massage, cupping, and qigong, each tailored to individual diseases and conditions. Students not only learn about herbs' properties, functions, and applications but also master skills like acupuncture and massage. Acupuncture regulates energy flow by stimulating specific points, while massage adjusts physiological and pathological states through manual techniques ^[3]. Higher TCM education focuses on cultivating comprehensive student qualities, emphasizing professional knowledge alongside humanities, ethics, and innovation. TCM culture stresses “medicine as a benevolent art,” requiring doctors to possess compassion, high ethical standards, and excellent skills. Courses in medical ethics and doctor-patient communication nurture professional ethics and empathy. Encouraging research participation enhances innovation and practical abilities. Additionally, visits to TCM museums and renowned practitioners' homes strengthen students' cultural confidence.

3.2. Diversified teaching methods

Higher TCM education innovatively employs various teaching methods. Curriculum integration breaks traditional disciplinary boundaries, combining foundational TCM theory, diagnostics, pharmacology, and formulas into comprehensive modules for systematic learning. Teaching content incorporates modern medical knowledge and research to enrich TCM instruction. For example, modern imaging technology can be introduced to enhance the understanding of tongue diagnosis. Multimedia lectures, online course browsing, and self-study methods extend knowledge retention and improve information literacy.

Diversified teaching models are applied. Case-based teaching develops clinical thinking and problem-solving skills through real-world examples. Teachers guide students in analyzing cases, formulating diagnoses, and designing treatment plans. Group discussions and role-playing enhance communication and teamwork. Problem-based learning (PBL) encourages independent learning and exploration through posed questions, improving research and analytical abilities. Flipped classrooms reverse traditional models, allowing students to study materials before class and engage in discussions, answer questions and solve problems, and conduct case analysis during sessions, fostering active learning and collaboration ^[4].

The combination of traditional apprenticeship with modern education integrates hands-on clinical training with formal academic learning. The “dual mentorship” system pairs school instructors for theoretical guidance with clinical mentors for practical instruction ^[5]. TCM culture is integrated into education through dedicated courses and activities, strengthening cultural identity and cultivating professional ethics ^[6].

3.3. Comprehensive teaching system

Firstly, highly qualified faculty. Most higher TCM institutions boast experienced teachers with strong clinical backgrounds who impart professional knowledge and guide clinical practice, nurturing clinical thinking and practical skills. Institutions actively recruit domestic and international talent to enhance faculty quality and teaching standards. A multi-level, multidisciplinary educational framework spans associate, bachelor's, master's, and doctoral degrees, promoting coordinated development across related fields. Secondly, advanced teaching facilities. With growing national support, higher TCM institutions have upgraded infrastructure, featuring modern classrooms, laboratories, and libraries that provide excellent learning environments. Advanced technologies like multimedia and virtual simulation systems further enhance teaching effectiveness.

3.4. Interdisciplinary integration

TCM integrates with modern medicine, biology, chemistry, physics, artificial intelligence, and other disciplines, broadening students' horizons and fostering innovative approaches. Combining with modern medicine promotes

effective integrated treatments; intersections with biology and chemistry deepen understanding of herbal mechanisms; information science supports TCM informatization through databases and intelligent diagnostic systems; psychology and sociology enhance awareness of psychological and social health factors. Such interdisciplinary fusion creates new opportunities for TCM development, addressing key issues and promoting global recognition of traditional Chinese medicine to better serve human health.

4. Shortcomings of current higher TCM education

4.1. Lack of cultural confidence

Influenced by modern science and Western medical concepts, some learners of TCM lack a deep understanding and recognition of TCM theories and practices, often doubting its scientific validity and effectiveness. They may prefer Western diagnostic and treatment methods over the unique theoretical framework of TCM, such as Yin-Yang and Five Elements, meridians, and Qi-blood, which they find difficult to explain through modern science. The educational system for TCM does not delve deeply enough into traditional culture, leading students to inadequately grasp the profound cultural heritage behind TCM, making it hard for them to firmly believe in TCM culture. Public opinion sometimes misinterprets or harbors prejudice against TCM, which can negatively affect learners' confidence in it. The current TCM education model is based on a Western medicine-dominated medical education system from the former Soviet Union. TCM differs greatly from Western medicine, not only in diagnostic and therapeutic methods but also in thinking patterns. Rooted in traditional culture, TCM's theories mainly stem from long-term clinical practice and rely on dialectical thinking for diagnosis and treatment, requiring doctors to use their judgment for the four diagnostic methods: observation, auscultation and olfaction, inquiry, and palpation. In contrast, Western medicine is based on modern science, where disease judgments are largely dependent on modern instruments and devices, primarily derived from experiments. These differences mean that TCM's knowledge structure, research methods, and treatment models cannot be equated with those of Western medicine. Therefore, higher TCM education modeled after Western teaching approaches has led to the loss of certain TCM characteristics.

4.2. Weak practical teaching components

TCM is a highly practical discipline, and practical teaching components are crucial for cultivating students' clinical skills and practical abilities. However, the practical teaching component in current higher TCM education remains relatively weak, mainly due to insufficient practical teaching time, incomplete construction of practical teaching bases, and a lack of practical teaching instructors^[7]. Currently, the cultivation of TCM talents primarily follows a higher TCM education model centered on academic education. In the current TCM education system, theoretical education often dominates. Students receive extensive instruction in TCM classical theories, formula studies, and pharmacology, but struggle to highlight TCM's clinical advantages. When students face clinical situations, they find it difficult to flexibly apply the theoretical knowledge they have learned, leading to "armchair strategizing." Additionally, some young teachers, despite holding doctoral degrees or postdoctoral positions, lack rich clinical experience and struggle to effectively integrate theory with practice, providing less vivid and practical guidance to students. Uneven distribution of teaching resources and insufficient clinical internship bases fail to meet the numerous students' practical needs^[8]. Throughout higher TCM education, there is an emphasis on theory over clinical practice, lacking academic debate, which contradicts the rules of TCM education. As calls for social development and educational reform grow, TCM education has gradually moved towards modernization, adopting similar enrollment, unified training,

and employment policies as other institutions, neglecting the uniqueness of TCM, which somewhat limits innovation. To ensure graduates possess strong clinical patient handling capabilities and adapt to societal demands, TCM colleges have added courses related to Western medicine, computers, and foreign languages. This has resulted in reducing the hours dedicated to ancient Chinese culture courses and TCM subjects, decreasing the time and energy spent on teaching and studying fundamental TCM theories based on classic texts, significantly affecting learning outcomes and resulting in unreasonable course settings. Following such a curriculum system, students neglect learning about Chinese traditional culture and related characteristic disciplines, poorly grasp basic TCM knowledge, and struggle to truly understand the essence of classics like the *Nei Jing* and *Shang Han Lun*. The “essence” of TCM gradually fades, and the trained medical students drift further away from pure TCM practitioners.

4.3. Insufficient faculty strength

Although higher TCM colleges possess a professional faculty team, with the continuous development of TCM education, faculty strength still falls short. On one hand, some teachers lack clinical practice experience, making it difficult to combine theoretical knowledge with clinical practice; on the other hand, there is a shortage of outstanding TCM talent to meet teaching demands. With the rapid expansion of higher TCM education scale and the sharp increase in student numbers, the growth rate of the faculty team cannot keep up. Many universities experience imbalanced teacher-student ratios, leading to large class sizes where teachers cannot adequately focus on each student during practical teaching segments. For instance, during clinical teaching, one instructor must simultaneously guide many students, drastically reducing students’ opportunities for actual operation. Taking some newly established local TCM colleges as examples, the number of admissions continues to rise, but talent recruitment faces challenges, and faculty reserves are insufficient, causing heavy burdens on foundational course teaching tasks and jeopardizing teaching quality. Faculty structure imbalance exists. In terms of age structure, a generational gap appears. On one hand, older generations of TCM experts gradually retire, possessing profound clinical experience and excellent medical skills but limited energy to sustain high-intensity teaching participation; on the other hand, there are insufficient mid-level and young backbone teachers who need time to grow and are yet unable to fully shoulder responsibilities. Professional structure is unreasonable; some schools concentrate TCM teachers in a few popular fields, such as internal medicine, while areas like orthopedics and acupuncture-massage have relatively weaker faculty, leading to insufficient professional guidance for students in these directions. Knowledge structure-wise, some teachers focus solely on theoretical teaching, lacking clinical experience. During clinical courses, they can only read from textbooks without closely integrating theory with actual cases, making it difficult for students to understand and master practical clinical skills. In TCM diagnosis courses, teachers without rich clinical experience find it challenging to vividly explain various diagnostic methods using real cases. Many university teachers directly enter teaching after graduation without sufficient clinical experience, leading to weak practical operational skills. In a highly practical discipline like TCM, teachers unable to proficiently demonstrate techniques like acupuncture and massage cannot provide precise practical guidance, hindering the development of students’ hands-on abilities. Surveys show that some university TCM faculty members have less than six months of average clinical practice within the past five years, making it difficult for them to convey the latest clinical experiences and skills to handle complex conditions, resulting in slow adaptation and long adjustment periods for students entering clinical work after graduation.

5. Suggestions and strategies

5.1. Enhancing TCM cultural confidence

Deepening the course teaching and strengthening the study of TCM classics. Increasing the weight of courses such as the *Huangdi Neijing*, *Shanghan Zabing Lun*, and *Shennong Bencao Jing*, employing diverse teaching methods like intensive reading, serial lectures, and discussions, guiding students to deeply comprehend the essence of the classics. For example, organizing case discussions on prescriptions from the *Shanghan Zabing Lun* and analyzing their applications in modern clinical conditions allows students to tangibly feel the vitality and practicality of the classics, thereby establishing firm confidence in the TCM theoretical system. Inviting renowned scholars and veteran TCM practitioners to deliver classic lectures, sharing their insights and clinical application experiences, inspiring students to explore the classics with exemplary influence, and helping them recognize the timeless value of the classics. Expanding TCM cultural courses. Offering courses on various TCM doctrines, TCM philosophy, and TCM folklore helps students understand the development history, cultural background, and social foundations of TCM. From its origins to historical inheritance and innovation, from the infiltration of traditional philosophical thoughts to the health wisdom contained in folk customs, comprehensively showcasing the profundity of TCM culture. For instance, in TCM history courses, narrating legendary stories of ancient famous doctors like Bian Que and Hua Tuo, as well as TCM's remarkable achievements in combating epidemics in different historical periods, instills pride in students regarding TCM's brilliant history. Utilizing local TCM cultural resources to develop distinctive school-based courses. If the school's location has unique TCM schools or medicinal herb resources, they can be integrated into the curriculum, bringing students closer to local TCM culture and enhancing their sense of identity and belonging.

5.2. Strengthening faculty team building

Firstly, enhancing talent recruitment and cultivation. Universities should broaden talent recruitment channels, not only recruiting excellent TCM talents domestically but also introducing overseas TCM experts with international perspectives. Meanwhile, formulating comprehensive plans for nurturing middle-aged and young teachers, dispatching them to renowned domestic and international medical institutions for further study, attending academic conferences, and participating in clinical practice to enhance their professional competence and practical skills. Secondly, optimizing faculty structure. Adjusting faculty age, specialty, and knowledge structures according to the school's professional development needs. Encouraging mentorship among senior, middle-aged, and young teachers, establishing team cooperation mechanisms, and promoting exchanges and collaboration among teachers from different professional fields. For instance, forming multi-disciplinary joint teaching research rooms in TCM to jointly conduct teaching research and practical guidance. Additionally, establishing incentive mechanisms. Setting up special reward funds to materially and spiritually reward teachers who excel in teaching, clinical practice, and research, tilting title evaluations and position promotions towards teachers with strong practical abilities and good teaching effects, motivating teachers to improve their own qualities.

5.3. Reinforcing practical teaching components

Increasing practical teaching time to ensure students have ample time for clinical practice. This can be achieved by adjusting teaching plans and increasing the number of practical teaching weeks to raise the proportion of practical teaching. Improving practical teaching base construction, strengthening cooperation with hospitals, clinics, and other medical institutions to establish stable practical teaching bases. This can be done through signing cooperation agreements and providing technical support to enhance the construction level of practical

teaching bases. Strengthening the construction of practical teaching guidance teacher teams, improving the professional levels and teaching abilities of practical teaching guidance teachers. This can be achieved by sending teachers to participate in practical teaching training and hiring clinical doctors as practical teaching guidance teachers to enrich the practical teaching guidance teacher teams. Adjusting course structures to avoid content repetition. Courses can be reasonably set based on the characteristics and needs of TCM majors, optimizing the course system. Updating course content to reflect the latest research results and developments in the field of TCM. This can be done by introducing cutting-edge TCM theories and technologies and inviting experts and scholars for lectures to enrich course content. Increasing the proportion of practical courses and strengthening the integration of theory and practice. This can be done by setting up clinical internships, experimental courses, and social practices to enhance students' practical abilities.

6. Conclusion and outlook

Higher TCM education bears the important task of inheriting and developing TCM, currently enjoying significant advantages while facing numerous challenges. TCM contains rich cultural connotations, building a solid foundation of TCM knowledge for students through classic texts, unique theories, and diverse therapies, cultivating TCM thinking and comprehensive qualities in students. Diversified teaching methods innovate continuously, integrating courses, utilizing modern technology, applying varied modes, and combining the strengths of traditional apprenticeship systems and modern education to stimulate students' enthusiasm for learning and practical abilities. A complete teaching system covering professional faculties and advanced facilities provides strong support for teaching, and interdisciplinary integration broadens horizons, injecting vitality into TCM innovation. However, problems cannot be ignored. Some students and practitioners lack TCM cultural confidence, impacted by modern science and Western medical concepts, compounded by the westernization of TCM education models, lack of traditional cultural education, misleading public opinions, leading to the dilution of TCM characteristics; weak practical teaching components, theory dominance, insufficient practice time, inadequate bases, and lack of faculty practical experience result in students' deficiencies in clinical skills; insufficient faculty strength, imbalanced teacher-student ratios, unreasonable structures, and weak faculty practical abilities fail to meet teaching demands. In response to these issues, deepening courses to strengthen TCM classic readings, expanding TCM cultural courses, and utilizing local ethnic TCM resources can enhance cultural confidence; broadening talent recruitment, nurturing middle-aged and young teachers, optimizing faculty structures, and establishing incentive mechanisms strengthen faculty team building; reinforcing practical teaching components from aspects of time, bases, faculty, and courses. Higher TCM education has the potential to reach new heights through continuous improvement. With the reconstruction of TCM cultural confidence, students will more deeply understand the essence of TCM, with a firm belief in inheriting TCM, allowing it to shine uniquely in the new era and become a bright card in the global health field. Through continuous optimization of faculty teams, gathering domestic and international elites, uniting old, middle-aged, and young individuals, balancing knowledge and practice, injecting inexhaustible wisdom power into TCM education, and steadily improving teaching quality. Strengthening practical teaching components will make students' clinical skills increasingly proficient, seamlessly connecting theory with practice, cultivating a large number of TCM talents capable of quickly adapting to clinical situations and solving practical problems, meeting society's growing health needs, and achieving coordinated prosperity in TCM education and TCM endeavors.

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Research on the College English Teaching Mode Based on the Integration of Language Learning and Critical Thinking Ability Training

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Abstract: Under the tide of economic globalization, college English teaching should not only focus on the improvement of language ability, but also on the cultivation of students' critical thinking ability. This paper takes the integration of language learning and critical thinking ability as the breakthrough point, explores the college English teaching mode under the background of the integration of the two, analyzes the current situation and disadvantages of the separation of the two in the current teaching, and puts forward the integration path from the aspects of curriculum design, teacher training, evaluation system, and so on. With the help of activities such as creating real language situations, carrying out debates and critical reading, it helps students strengthen the improvement of logical analysis and critical thinking ability in their gradual learning, realize the coordinated development of language learning and critical thinking ability, and cultivate compound talents with both language literacy and critical thinking ability for the society.

Keywords: Language learning; Critical thinking ability; Integration; College English; Teaching model

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1. Introduction

Under the background of the intelligent era, globalization has become an inevitable trend. At present, driven by both, language learning is no longer limited to the simple tool category, and has gradually become an important carrier for cultivating cross-cultural critical thinking ability. The traditional college English teaching mode is single and focuses on the mechanical input of language knowledge and skill training. There is a lack of motivation in the cultivation of core qualities such as logical reasoning and critical thinking, which cannot meet the training needs of compound talents in the new era. With the deepening reform of higher education and the increasing demand for comprehensive quality talents, how to deeply integrate language learning and critical thinking ability training and build a more innovative and effective teaching mode has become an important issue to be solved. Based on the internal relationship between language education and thinking development, this paper analyzes the significance and current situation of college English teaching, and explores the path and

method of organically integrating the cultivation of critical thinking ability into the whole process of language teaching, aiming to provide theoretical and practical reference for improving the quality of college English teaching and cultivating high-quality talents with international vision and critical thinking ability.

2. Significance of exploring the college English teaching mode under the integration of the two

2.1. Improving students' comprehensive language literacy

Traditional college English teaching focuses more on the teaching of language knowledge, paying more attention to students' mastery of vocabulary, grammar, and other basic content, but it is inevitable that there will be "high scores but low abilities" in practical application. The teaching mode of integrating language learning and critical thinking ability training can effectively improve this situation ^[1]. In this mode, students are no longer limited to mechanically memorizing language rules, but through in-depth thinking, analysis, and discussion of various topics, take language as a carrier to strengthen thinking, and improve the accuracy, fluency, and flexibility of language use in the process of expressing views and demonstrating ideas. For example, in class debate, students need to use English to organize rigorous logical argumentation and accurately express complex views, which not only exercises their language expression ability, but also enables students to deepen their understanding of language structure and semantic connotation in language practice, truly realize the coordinated development of language knowledge and language skills, and significantly improve their comprehensive language literacy ^[1].

2.2. Improving students' critical thinking

Critical thinking ability is the comprehensive embodiment of students' critical thinking, creative thinking, and other high-level thinking abilities, which has a profound impact on students' lifelong learning and personal development. In the traditional English classroom, students are often in a situation of passive acceptance of knowledge, lack of opportunities for independent thinking and active exploration, and the development of thinking ability is limited. The teaching mode of integrating language learning and critical thinking ability provides students with rich thinking training scenes ^[2]. By designing open-ended questions, guiding case analysis, organizing group discussions, and other teaching activities, teachers encourage students to break through their inherent thinking patterns, examine problems in an all-round way, and put forward innovative opinions from different levels. When analyzing literary works, students' understanding of the literal meaning of the text is the basis. More importantly, they should deeply explore the cultural connotation and social significance behind the works, and critically evaluate the author's views and creative techniques. This critical process effectively improves students' logical reasoning, analytical judgment, and innovative thinking ability, so that students can continuously develop their thinking in language learning, improve their cognitive social ability, and lay a solid thinking foundation for their future academic research and career development ^[2].

2.3. Meeting the needs of social talents

With the rapid development of the times and the continuous progress of society, the requirements for talents are increasingly diversified and comprehensive. In the context of globalization, frequent international exchanges and cooperation have become the norm. The society needs not only talents with good English language skills, but also compound talents who can use English for efficient communication, independent thinking, and innovative problem solving. The college English teaching mode that integrates language learning and critical

thinking ability training conforms to the trend of social demand for talents. The students trained under this teaching mode can accurately express their views in English in international business negotiations, cross-cultural academic exchanges, and other scenes. At the same time, with strong speculative ability, they can deeply analyze the nature of the problem, put forward practical solutions, and show stronger competitiveness and adaptability in the workplace. This kind of teaching mode will help colleges and universities provide more high-quality talents that meet the needs of the times for society, and promote the long-term development of the country in the international competition ^[3].

2.4. Promoting college English teaching reform

For a long time, there have been some problems in college English teaching, such as single teaching objectives, outdated teaching methods, and so on. The teaching mode of integrating language learning and critical thinking ability training provides new ideas and directions for college English teaching reform. This mode requires teachers to innovate teaching ideas, change from knowledge imparters to learning guides, pay more attention to students' dominant position and ability training, promote teachers to innovate teaching methods, adopt diversified teaching methods such as task-driven and project-based learning, and create a positive and active classroom atmosphere. At the same time, it also promotes the improvement of the curriculum evaluation system, from the single language knowledge assessment to the comprehensive evaluation of students' language ability and critical thinking ability ^[3]. The exploration and practice of this teaching mode will effectively promote the transformation of college English teaching from the traditional mode to a modern and diversified mode, improve the quality and level of college English teaching, and promote the connotative development of higher education ^[4].

2.5. Promoting cultural inheritance and exchange

There is no doubt about the importance of language learning. It is the carrier of culture. College English teaching not only shoulders the important task of language teaching, but also undertakes the mission of cultural communication. Under the teaching mode of integrating language learning and critical thinking ability, students should learn to treat different cultural connotations dialectically in the process of learning English language and Western culture, and be able to use critical thinking to compare and analyze Chinese and Western culture, so as to have a more objective and comprehensive understanding of western culture and avoid blind worship or one-sided cognition. At the same time, when using English to express their views and participate in international exchanges, students will also take the initiative to think about and spread their own culture, enhance cultural confidence in cross-cultural exchanges, and realize equal dialogue, exchange, and mutual learning between different cultures. It will help promote Chinese culture to the world, promote the diversity of world culture, and show the unique charm of Chinese culture on the international stage ^[5].

3. Status analysis

Today, with the accelerating process of globalization, the demand for high-quality talents with international vision, intercultural communication ability, and critical thinking is growing. As an important part of higher education, college English teaching aims not only to impart language knowledge and improve students' language skills, but also to cultivate students' critical thinking ability so that they can think independently and communicate effectively in multicultural communication ^[4]. College English teaching mode, which integrates language learning and critical thinking ability training, has gradually become a research hotspot and

reform direction in the field of education. However, in the actual teaching process, the implementation of this integration mode faces many opportunities and challenges that need to be solved.

The choice of teaching methods has a direct impact on the integration effect of language learning and critical thinking ability training. At present, although the college English classroom teaching methods show a diversified trend, there are still deficiencies in cultivating students' critical thinking ability. On the one hand, teachers rely more on textbooks in teaching, so the teaching content inevitably has limitations and lacks the expansion and innovation of teaching resources. It makes the teaching content lack modernity and interest, and it is difficult to stimulate students' interest in learning and speculative enthusiasm. For example, in reading teaching, teachers tend to focus on the understanding of the details of the article and the analysis of language points, but ignore guiding students to analyze and evaluate the theme, views, and logical structure of the article. On the other hand, group discussion, project-based learning, and other teaching methods that can cultivate students' critical thinking ability are formalized in practical application. In the group discussion, some students lack the enthusiasm to participate, and the content of the discussion is often superficial, failing to really explore the problem in depth, and failing to achieve the expected effect of cultivating critical thinking ability^[6].

As an important carrier of teaching, the content and arrangement of college English textbooks play a key role in the implementation of the integration mode of language learning and critical thinking ability training. At present, some college English textbooks fail to fully reflect the times and diversity in content selection, and lack in-depth discussion on topics with in-depth significance such as social development and cultural exchange, which is difficult to arouse students' thinking and in-depth exploration. In the arrangement of textbooks, the systematic and hierarchical attention to the cultivation of critical thinking ability is insufficient, and the students' critical thinking consciousness is not gradually guided according to their cognitive level and language ability. For example, the speculative exercises in some textbooks are scattered and lack clear goals and guidance, so students often feel unable to start and effectively exercise their speculative ability when completing the exercises.

4. Analysis on the construction path of college English teaching mode integrating language learning and critical thinking ability training

4.1. Reconstructing the curriculum system and strengthening the speculative-oriented module

At the level of curriculum design, we should have the courage to break through the single framework of traditional "reading, writing, and translation" skills training and build a curriculum module with the development of critical thinking ability as the core. First of all, a special critical English course is set up to systematically cultivate students' high-level thinking abilities such as analysis, reasoning, and evaluation through special training such as academic debate and critical reading. For example, we will conduct in-depth discussions on controversial topics such as "the impact of artificial intelligence on social ethics" and "cultural identity in the context of globalization," and guide students to use English for multi-dimensional argumentation. Secondly, the critical task is embedded in the general English course, which combines listening training with information analysis, oral practice with opinion expression, and writing training with logical construction. For example, in listening teaching, a three-step task chain of "point of view capture–logical analysis–critical response" is designed, which requires students to identify logical loopholes in information and put forward refutation opinions on the basis of understanding the content^[5]. In addition, we should develop interdisciplinary theme courses, integrate the contents of literature, sociology, science, and technology, and encourage students

to use English to carry out interdisciplinary thinking. For example, in the course of “future society in science fiction,” we should guide students to analyze the technical ethics problems in the text and make cross-cultural comparisons.

4.2. Innovating teaching methods and creating an interactive speculative classroom

Classroom teaching should change from “knowledge transfer” to “thinking collision,” and adopt diversified teaching methods to stimulate speculative vitality. The Socratic Questioning method can effectively guide students’ in-depth thinking. Teachers can promote students’ rational reflection by continuously asking questions such as “what is your basis?” and “does this conclusion have limitations?” For example, when discussing “the impact of social media on interpersonal communication,” teachers can guide students to analyze from multiple perspectives such as psychology and communication through questioning. Project-based learning (PBL) is a deep integration of language application and speculative tasks. For example, the project of “designing an international cooperation scheme to solve the problem of garbage classification on campus” is arranged. Students are required to use English to carry out research, analyze data, propose schemes, and carry out feasibility demonstration. Debate and group discussion are important forms of cultivating critical thinking ability. Teachers can design debate questions such as “can online education replace traditional classroom,” and exercise students’ logical construction and ad hoc refutation ability through the confrontation of positive and negative views. At the same time, group case analysis is used to promote students’ critical thinking in the collision of views.

4.3. Optimizing the evaluation system and establishing a multidimensional speculative evaluation mechanism

The traditional evaluation method based on language accuracy is difficult to measure the development of critical thinking ability, so it is necessary to build a multi-dimensional system, including process and summative evaluation. In terms of process evaluation, a learning portfolio is established to collect students’ classroom speech records, debate drafts, reflection logs, and other materials, and the dynamic evaluation is carried out from the perspectives of innovation, logical rigor, and adequacy of argument. For example, by analyzing the frequency of students’ statements in group discussions and the trajectory of their views, we can judge their speculative participation. The summative evaluation can adopt the structured scoring standard to weight the language ability and critical thinking ability respectively. For example, in the argumentative writing score, the language expression accounts for 40%, and the logical structure, opinion depth, and critical thinking account for 60%. In addition, the peer evaluation and self-evaluation mechanism is introduced, and students are required to score the performance of group discussion and peer speeches according to the critical thinking ability evaluation scale, and write a reflection report to improve their critical thinking consciousness in evaluating others and self-reflection.

4.4. Improving teachers’ quality and strengthening speculative teaching ability

As the key to the reform of teaching mode, teachers need to improve their critical teaching ability through systematic training. Colleges and universities can organize teachers to participate in critical thinking ability training workshops, learn Bloom’s taxonomy of educational objectives, critical thinking theory, and other knowledge, and master Socratic Questioning, debate teaching, and other methods. Teachers are encouraged to carry out action research, explore the teaching strategy of the integration of language and speculation with the

classroom as the experimental field, such as designing the integrated teaching unit of “reading–discussion–writing,” and optimizing the teaching effect through teaching reflection and data analysis. Establish a teacher collaboration community to share speculative teaching resources and experience through collective lesson preparation, teaching observation, case study, and other activities. For example, an interdisciplinary teacher team was established to jointly develop a teaching case library that integrates language and speculation, covering multiple topics such as technology, culture, and society, and providing rich materials for teaching practice.

4.5. Improving the supporting environment and adding a digital speculative learning platform

Relying on modern information technology, create an online and offline speculative learning ecosystem. Develop a special speculative English learning platform, integrate a debate video database, an academic paper corpus, online debate tools, and other resources, and support students’ autonomous learning and collaborative exploration ^[6]. For example, the platform is equipped with a “viewpoint arena” module, where students can upload debate videos. The system analyzes indicators such as language fluency and logical structure through artificial intelligence technology, and provides suggestions for improvement. Use virtual simulation technology to create cross-cultural speculative scenes, such as simulated United Nations conferences, international business negotiations, and other situations, so that students can improve their language use and critical ability in immersive interaction. At the same time, establish a cloud discussion area for real-time interaction between teachers and students, encourage students to carry out real-time speculative communication around hot topics, and teachers provide guidance and feedback in time to form a continuous speculative learning atmosphere.

5. Conclusion

The college English teaching mode integrating language learning and critical thinking ability training is the due meaning of the development of the times and the inevitable trend of college education and teaching reform. It not only meets the needs of talent training in the new era, but also builds a bridge for students’ cross-cultural communication and in-depth thinking. It can effectively improve students’ language use ability and logical thinking level, break the limitations of traditional language learning, and realize the leap from acquiring language knowledge to shaping thinking ability. In the future, college English teaching should continue to explore and deepen this mode, further optimize the curriculum design and teacher-student interaction, and help students grow into compound talents with international vision and critical thinking ability while improving their language literacy, so as to better adapt to the challenges and opportunities in the era of globalization.

Disclosure statement

The author declares no conflict of interest.

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Problems and Coping Strategies of Mechanical Drawing Courses in Vocational Colleges

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Abstract: With the economic and social development of the country, vocational education is playing an increasingly significant role in cultivating highly skilled talents. However, the mechanical drawing courses in vocational colleges still face numerous challenges in the teaching process, such as outdated textbook content, inadequate practical resources, weak teaching staff, and low student interest. This paper aims to explore these issues and propose corresponding coping strategies. The findings of this study not only provide specific improvement suggestions for vocational colleges but also emphasize the importance of these strategies in enhancing students' comprehensive abilities and promoting the development of vocational education. By addressing these challenges, this paper contributes to the enhancement of teaching quality and the overall advancement of vocational skills education.

Keywords: Mechanical Drawing courses; Mechanical drawing; Problems; Strategies

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1. Introduction

Vocational education is a critical part of the modern educational system, equipping students with practical skills to meet market demands and address employment challenges. Amidst globalization and technological progress, there is heightened emphasis on technical talent cultivation globally; this need underscores vocational education's importance due to industrial upgrades. Vocational training aligned with industry needs promotes labor market balance and economic development.

Mechanical drawing, essential in engineering design and manufacturing, facilitates communication among engineers and manufacturers while fostering students' spatial imagination, logical thinking, and practical skills. Mastery of mechanical drawing is foundational for vocational college students' future careers in related fields^[1,2]. However, current teaching practices face issues: textbook content lags behind industry trends, practical resources are insufficient, teaching staff lack comprehensive expertise, and traditional modes fail to engage student interest. These factors undermine teaching quality and impede skill development. This study analyzes these issues and proposes strategies to enhance vocational education, aiming to improve overall teaching

standards in the field.

2. Related research

Previous scholars have conducted extensive research. For example, Song *et al.* ^[3] developed online open courses for mechanical drawing in Chinese colleges via the XuetangX MOOC platform, integrating outcome-based education and diverse interactive elements since March 2018. Xu *et al.* ^[4] introduced a Unity3D-based virtual simulation system for mechanical disassembly, overcoming issues such as high costs and safety risks, which enhanced student engagement and learning efficiency through interactive simulations. Chen ^[5] examined engineering graphics teaching reform by leveraging big data and certification to boost educational quality and prepare students for professional accreditation. Zhuo *et al.* ^[6] constructed a 3D holographic digitization system for mechanical drawings, offering an intuitive platform that enriched the lifecycle management of mechanical products from design to manufacturing. Lastly, Xu *et al.* ^[7] applied smart education technology in blended teaching for engineering drawing, enhancing traditional methods and significantly improving student engagement and the informatization of teaching processes based on OBE principles. These studies provide valuable insights for this research.

3. Challenges faced

In the realm of mechanical drawing courses in vocational colleges, several significant challenges impede the effective transmission of knowledge and skills to students. These challenges, if not addressed, can hinder the overall progress and relevance of the curriculum. This chapter delves into the primary issues that need to be tackled for the enhancement of mechanical drawing education.

3.1. Lagging textbook updates

With the rapid evolution of technology, the standards and tools utilized in mechanical drawing are continuously undergoing transformations. However, textbooks employed in vocational colleges often lag behind, resulting in a substantial disconnect between the instructional content and the actual demands of the industry. For instance, some textbooks may still focus heavily on traditional manual drafting techniques while neglecting the application of modern Computer-Aided Design (CAD) software. The lag not only hampers students' acquisition and comprehension of the latest technologies but also potentially renders them less competitive in the job market. Furthermore, the cases and projects presented in textbooks tend to be overly theoretical, devoid of practical application contexts, making it difficult for students to apply their learned knowledge in real-world work environments.

3.2. Inadequate practical resources

Practical application is an integral component of mechanical drawing courses, yet many vocational colleges struggle to provide adequate practical resources. Firstly, laboratory equipment is either outdated or insufficient in quantity to cater to the needs of all students. Secondly, advanced drafting software and related hardware come at a high cost, which schools may find difficult to bear. These factors limit opportunities for hands-on experiences, thereby impacting the cultivation of students' skills. Additionally, even when equipment and software are available, a lack of sufficient training and support can hinder both teachers and students from fully utilizing these resources.

3.3. Weak teaching staff

The quality of teaching staff is one of the pivotal factors influencing the quality of mechanical drawing education. Currently, many mechanical drawing instructors in vocational colleges face the following issues: firstly, their professional knowledge is not updated in a timely manner, making it challenging for them to impart the latest technologies and standards; secondly, their teaching methods are monotonous, relying heavily on traditional lecture-based approaches that lack interactivity and practicality. These problems contribute to a suboptimal learning experience for students and fail to ignite their interest in learning.

3.4. Insufficient student engagement and interest

Traditional teaching models often revolve around the teacher as the centerpiece, emphasizing the impartation of knowledge while neglecting active student participation and interest cultivation. This model can easily render students disinterested and devoid of motivation. Especially in practical courses like mechanical drawing, students struggle to truly grasp and master the learned knowledge if they are not fully engaged in hands-on activities.

4. Coping strategies

Addressing the multifaceted challenges faced by mechanical drawing courses in vocational colleges necessitates a comprehensive and proactive approach. This chapter outlines several coping strategies aimed at enhancing the relevance, engagement, and effectiveness of these courses.

4.1. Updating teaching materials

To ensure that the content of mechanical drawing courses remains synchronized with industry demands, educational institutions should establish a mechanism for continuously updating teaching materials. Schools should form dedicated committees responsible for reviewing textbooks annually or semesterly and updating them based on the latest industry standards and technological developments. Committee members can include in-house teachers, industry experts, and student representatives. Multimedia resources such as video tutorials, online simulation software, and interactive learning platforms should be leveraged to enrich teaching methods. These resources not only provide a more intuitive learning experience but also facilitate students' understanding of complex concepts. Encouraging the development and use of electronic textbooks facilitates rapid updates and distribution. Electronic textbooks can also include links to external resources such as industry standard documents, case studies, and technical articles, thereby enhancing students' self-directed learning capabilities. Through these measures, the timeliness and practicality of teaching content can be ensured, ultimately improving students' learning outcomes and employment competitiveness.

4.2. Implementing project-based learning

Project-based learning (PBL) is an effective teaching method that stimulates students' interest and initiative by engaging them in real or simulated engineering projects. Suitable projects should be selected based on course objectives and students' ability levels. These projects can be real-world tasks sourced from enterprises or simulated engineering projects. Students should be divided into groups, with each group responsible for completing a specific project task. This approach not only exercises students' teamwork abilities but also allows them to learn problem-solving skills through practice. Teachers should provide necessary guidance and support throughout the process, regularly checking on project progress and giving timely feedback. Additionally,

industry experts can be invited to review the projects and provide professional insights. Upon completion, an exhibition should be organized for students to present their work and share experiences, which can help boost their self-confidence and presentation skills. Through PBL, students can apply their learned knowledge in practical operations, enhancing their practical abilities and innovative thinking.

4.3. Enhancing course interactivity

Traditional lecture-based teaching often lacks interactivity, making it difficult to stimulate students' interest in learning. Therefore, enhancing course interactivity is one of the crucial pathways to improving teaching. Discussion sessions should be set up in the classroom, where students can communicate around specific topics or questions. This not only promotes communication among students but also cultivates their critical thinking abilities. Introducing real engineering cases can guide students in analyzing and solving practical problems. Through case analysis, students can better understand the application of theoretical knowledge and learn to handle complex situations. Role-playing exercises, where students simulate roles such as engineers and project managers, can help them experience the work content of different positions. This method can enhance students' sense of immersion and improve their understanding of careers. Tools such as interactive whiteboards and online voting systems can be utilized to increase classroom interactivity. These tools can help teachers monitor students' learning status in real-time and adjust teaching strategies accordingly. Through these interactive methods, the classroom can become livelier and more engaging, thereby improving students' learning enthusiasm.

4.4. Integrating competitions into classroom teaching

Competitions are an effective means of testing students' skills and stimulating their interest in learning. Incorporating the topics of "Mechanical Drawing Competitions" into classroom teaching offers numerous benefits. Participating in competitions allows students to hone their drawing skills and problem-solving abilities in high-pressure environments, which is highly beneficial for enhancing their comprehensive abilities. Students who excel in competitions can receive certificates and rewards, positively impacting their future academic pursuits and employment prospects. This incentive mechanism can spark the learning enthusiasm of more students. Through classroom promotion and mobilization, more students can be made aware of and encouraged to participate in competitions, thereby expanding their influence. Schools can collaborate with competition organizers to obtain additional resource support, such as training materials and expert lectures, further enhancing teaching quality. By integrating competitions with classroom teaching, we can greatly motivate students, especially the outstanding ones, to learn more actively. Additionally, combining competitions with daily teaching provides students with more practical opportunities and room for development.

4.5. Comprehensive teacher capability enhancement

To improve the quality of the teaching staff, schools can adopt the following measures. Teachers should be regularly organized to participate in domestic and international academic exchange activities to enhance their professional expertise and teaching abilities. Industry experts should be hired as part-time teachers to bring the latest practical experience and technical knowledge into the classroom. Teachers should be encouraged to adopt innovative teaching models such as PBL and flipped classrooms to increase student engagement and enthusiasm.

5. Conclusion

This paper has systematically analyzed the primary issues confronting mechanical drawing courses in vocational colleges and proposed a multitude of practical and feasible countermeasures. The research reveals that lagging textbook updates, inadequate practical resources, a weakened teaching faculty, and insufficient student interest are the major obstacles in current teaching practices. To address these challenges, several recommendations have been suggested, including the regular review and updating of textbooks, the integration of multimedia resources, the implementation of project-driven learning and the enhancement of classroom interactivity, the incorporation of competition-based problems to bolster students' practical experience, and intensified teacher training efforts.

The findings of this study provide vital insights and serve as a crucial reference for the improvement of mechanical drawing courses in vocational colleges, potentially leading to more effective and engaging educational experiences for students, and ultimately, fostering a more skilled and prepared workforce in the technical and vocational fields.

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Focusing on Interdisciplinary Application Abilities: “Promoting Research through Courses” as a New Path for Cultivating Professional Degree Postgraduates

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Abstract: Currently, talent cultivation faces numerous challenges, such as a shortage of school-enterprise tutors and a disconnection between curriculum construction and industry demands. The “promoting research through courses” model has emerged in response to these challenges. Its goals include training students’ research capabilities, cultivating their interdisciplinary learning and application abilities, and establishing an ecological closed loop between education and research. The reform measures involve innovating curriculum design to create new, advanced, and practical courses, adopting a hierarchical and progressive classroom teaching method combined with post-class diversion guidance, and conducting online-offline integrated case-based and scenario-based teaching. The reform has achieved remarkable results. Students have enhanced their research abilities, knowledge application, and professional qualities. Schools have strengthened their discipline construction, teaching staff, and social influence. Enterprises have realized their talent reserves and technological innovations. The teaching model has integrated theory and practice, promoting the high-quality development of education and teaching, and providing a new path to solve the problems in education and industry development.

Keywords: Promoting research through courses; Interdisciplinary and applied talents; Curriculum reform

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1. Introduction

The “Professional Degree Postgraduate Education Development Plan (2020–2025),” jointly issued by the Academic Degrees Committee of the State Council and the Ministry of Education, requires improving the ability level of professional degree postgraduates. Interdisciplinary integration is conducive to realizing interdisciplinary knowledge exchange and innovation, aligning with national strategies, promoting the cultivation of new engineering talents, and facilitating education reform and industrial upgrading ^[1]. To meet the needs of the social economy and enterprise development for creative applied talents ^[2], it is necessary to

strive to promote talent cultivation reform. This requires constructing a collaborative education system, opening up school-enterprise cooperation education channels, and cultivating a collaborative classroom culture^[3], thus enhancing the quality of education. However, exploring implementation methods and breakthrough points that can improve the quality of postgraduate training, achieve efficient interdisciplinary education, and are operable for most universities remains a challenging task. Currently, there are still some deficiencies in the reform and exploration of applied talent cultivation^[4].

The innovation of professional degree postgraduate training cannot be achieved without high-level tutors. However, currently, there are problems among school-enterprise tutors, such as emphasizing theory over practice, a lack of communication, and having insufficient quantity and quality. In this situation, leveraging the advantages of multiple teachers and resources to build high-level signature courses and promote them is a viable talent cultivation path.

At present, China's postgraduate education cannot fully meet the diverse needs of economic and social development, and postgraduate-stage learning has not significantly contributed to students' subsequent career development^[5]. "Strengthening curriculum construction, emphasizing the role of curriculum teaching in postgraduate training, and strengthening the training of postgraduates' scientific methods and academic qualities through high-quality curriculum learning"^[6] has become an important measure to improve the quality of postgraduate training. However, it remains a difficult problem in teaching practice to carry out effective curriculum construction based on China's actual situation^[7]. In the context of the integration of industry and education, the curriculum structure of universities needs to be adjusted. It should be combined with industry demands, and universities should jointly design curriculum content with enterprises, increase practical courses, and innovate curriculum content to achieve the unity of knowledge and ability^[8].

The emergence of "promoting research through courses" brings hope for solving the problems in postgraduate curriculum construction. It combines courses with scientific research and is expected to break the deadlock in school-enterprise cooperation and promote the integration of industry and education. This article will explore its connotation, implementation path, and effectiveness, providing a reference for the development of education and industry.

2. The goal orientation of the "promoting research through courses" reform

2.1. Training research abilities

"Promoting research through courses" focuses on the comprehensive cultivation of students' research abilities and plays a crucial role in teaching practice. The curriculum is designed around the actual needs of enterprises and cutting-edge industry technologies. By introducing real-world enterprise project cases, students are exposed to industry challenges. For example, in the Energy Internet and Smart Grid Technology course, a postgraduate course that teaches about the current development status, challenges, technological trends, and countermeasures of the power energy system, which is the hub for achieving the "dual-carbon" goal, is based on the integration of multiple disciplines such as electrical engineering, control engineering, energy and power, electronic information, meteorology, and management, as well as the integration of universities and enterprises, and theory and practice, as shown in **Figure 1**.

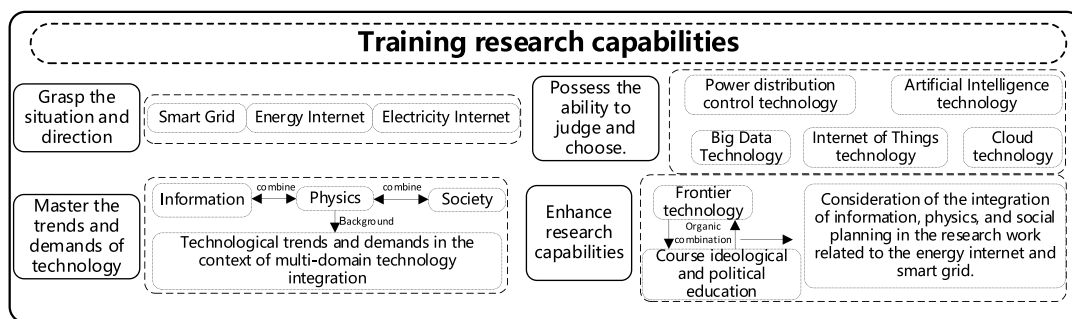


Figure 1. Training research ability with the Energy Internet and Smart Grid Technology course as an example

In the process of curriculum learning, students are no longer limited to mastering theoretical knowledge. Instead, they are project-oriented and go through a complete scientific research process from problem-raising, solution-design, and technology-selection to practice-verification. Under the joint guidance of teachers and enterprise mentors, students learn to use professional knowledge to analyze project requirements, select and apply appropriate cutting-edge technologies to solve practical problems, and exercise scientific research skills such as literature research, experimental design, and data analysis.

2.2. Cultivating interdisciplinary learning and application abilities

In the “promoting research through courses” model, universities and enterprises collaborate to develop teaching content aligned with curriculum goals, integrating real enterprise projects and technical requirements into the curriculum. This model dismantles the information barrier between schools and enterprises. Enterprise mentors actively participate in curriculum instruction, working alongside university educators to guide students.

The two sides regularly exchange information during teaching and research, sharing the latest industry trends, technical challenges, and academic research findings. By participating in project-chain-based teaching, students progressively acquire the applied skills necessary for interdisciplinary knowledge, spanning project conception, design, and implementation. In cooperative inquiry-based learning, students from diverse disciplinary backgrounds interact with one another, generating new ideas and expanding their problem-solving perspectives. Converting multi-disciplinary knowledge into practical outcomes not only enhances students’ abilities to learn and apply interdisciplinary skills but also fosters their innovative and practical competencies.

2.3. Establishing an ecological closed loop of “education feeding back into research and research upgrading education”

Under the “promoting research through courses” model, students apply the theoretical knowledge learned in class to actual enterprise research and development projects. By solving technical problems in the R&D process, students not only deepen their understanding of professional knowledge but also enhance their scientific research and practical skills, creating valuable feedback from education to research.

New challenges and demands arising from enterprise R&D processes offer rich and cutting-edge cases and research topics for curriculum instruction. Universities can then update teaching content and optimize the curriculum system based on these, allowing education to keep pace with industry technological development trends and achieve the advancement of teaching through research.

3. The reform measures of “promoting research through courses”

3.1. Curriculum design

In the curriculum design of “promoting research through courses,” a unique and forward-looking concept is adhered to. On the one hand, efforts are made to clearly present a complete set of methodologies and knowledge “technology trees” to students. In terms of curriculum content selection, it closely follows the trend of the times, integrating emerging advanced technologies such as artificial intelligence, big data analysis, and blockchain applications, and introducing advanced industry routes and cutting-edge concepts, enabling students to access the most advanced knowledge systems and keep abreast of industry trends. In the teaching implementation process, great importance is attached to the all-around cultivation of students’ professional abilities, professional qualities, and professional thinking.

The curriculum design also focuses on creating remarkable features of “newness,” “advancement,” and “practicality.” “Newness” is reflected in the up-to-date curriculum content and teaching methods, constantly updating the knowledge system and using new teaching means such as online-offline hybrid teaching and virtual simulation teaching. “Advancement” emphasizes that the teaching process is always guided by advanced technology trends, ensuring that university teaching is closely aligned with enterprise demands. “Practicality” is realized through the emphasis on practical teaching. Students can accumulate rich practical experience through enterprise internships and participation in actual projects, truly applying what they have learned and laying a solid foundation for future career development. The curriculum design concept is shown in **Figure 2**.

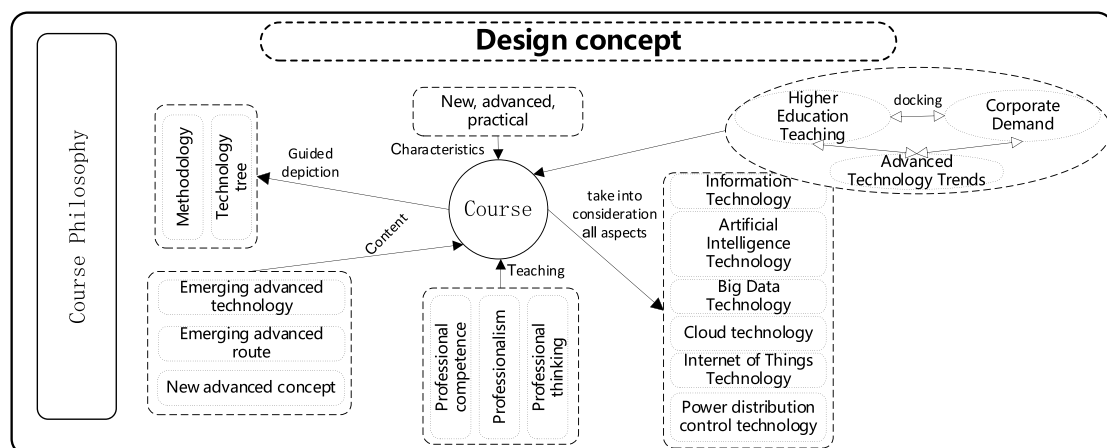


Figure 2. Course content and teaching method design

3.2. Hierarchical setup and progressive classroom teaching + post-class specialized diversion guidance

During the classroom teaching stage, by leveraging the advantages of multiple teachers (university professors, enterprise technical experts, and industry specialists) and multiple resources, a hierarchical setup and progressive teaching framework are constructed. University professors impart professional theories, enterprise technical experts share practical cases, and industry specialists introduce cutting-edge trends. The curriculum content is designed with gradually deepening knowledge points and problem situations according to teaching goals and students’ cognitive levels.

After class, specialized diversion guidance is carried out. According to students’ interests, professional foundations, and career plans, students are divided into different specialized groups, and a guidance team composed of university teachers and enterprise mentors provides targeted guidance. For students interested

in academic research, teachers guide them to explore theoretical issues in the curriculum, conduct academic research, and write academic papers. For students inclined to practical applications, enterprise mentors lead them to participate in actual enterprise projects for technology development and operation.

3.3. Online-offline integrated case-based and scenario-based teaching

Representative real-world engineering/scientific research cases covering different scales, technical difficulties, and application fields are collected and screened. Based on the content of these cases, scenario-based teaching situations are constructed. Through multimedia demonstrations, field visits, and project simulations, students can experience the actual operation of engineering/scientific research projects.

Taking the Energy Internet and Smart Grid Technology course as an example, enterprise experts and industry experts teach students real-world engineering/scientific research cases. The teaching process integrates curriculum-based ideological and political education, enabling students to understand the hard work and build the world's largest-scale power grid. This enhances students' sense of reality, encourages them to face real problems, guides them to solve bottleneck problems, and thus, inspires their patriotism. During the teaching process, online and offline interactions are carried out through on-site or remote access to enterprise project cloud platforms and the software and hardware resources of school-enterprise joint laboratories.

4. The reform achievements of “promoting research through courses”

4.1. From the student's perspective

The “promoting research through courses” reform benefits students the most. In terms of research capabilities, students learn to independently discover, analyze, and solve complex problems through participating in actual projects and scientific research processes in courses. Through project participation, students develop the ability to independently face industry technical challenges. Their knowledge application ability is also significantly enhanced, and the theoretical knowledge they have learned can be flexibly applied in practical scenarios. At the same time, project participation enriches students' resumes, which is of great help for future employment.

In addition, students' professional qualities are comprehensively cultivated. Participating in enterprise projects and team collaborations enables students to understand the importance of teamwork and communication, respect others' opinions, give full play to their respective advantages, and improve work efficiency. Facing project challenges, students gradually develop perseverance and an innovative spirit, actively exploring new methods and ideas.

4.2. From the school's perspective

Schools have achieved fruitful results in the “promoting research through courses” reform. In terms of discipline construction, through in-depth cooperation with enterprises, schools can promptly understand the latest industry technologies and demands, integrate them into the curriculum system and scientific research projects, and promote the renewal and innovation of discipline knowledge. For example, the Energy Internet and Smart Grid Technology major integrates the industry's “dual-carbon” goal requirements and opens up relevant cutting-edge research directions, enabling discipline development to keep up with the pace of the times.

4.3. From the enterprise's perspective

Enterprises have also obtained tangible benefits from the “promoting research through courses” reform. In terms of talent reserve, enterprises can contact and screen outstanding students in advance through participating

in curriculum teaching and project guidance, achieving precise talent cultivation and reserve. Enterprise mentors can deeply understand students' professional abilities and comprehensive qualities during the guidance process, facilitating the selection of suitable talents for enterprises.

4.4. From the teaching model's perspective

“Promoting research through courses” has promoted the innovation and development of teaching models. Traditional teaching models focus on theoretical knowledge imparting, while “promoting research through courses” realizes the in-depth integration of theory and practice. Multiple teaching models complement and develop synergistically, forming a diversified teaching model system, providing useful references for education and teaching reform, and promoting the high-quality development of education and teaching.

5. Retrospect and prospects

In the context of the integration of industry and education, “promoting research through courses” provides an innovative solution to the problems in professional degree postgraduate education. Aiming to train research capabilities, cultivate interdisciplinary learning and application abilities, and build an ecological closed loop of education and research, it has achieved remarkable results through measures such as curriculum design, hierarchical teaching with diversion guidance, and online-offline case-based teaching. Students' abilities and qualities have been enhanced, schools' discipline construction and teaching staff have been strengthened, enterprises have achieved talent reserve and technological innovation, and the teaching model has witnessed innovative development.

In the future, it is necessary to further promote the “promoting research through courses” model, continuously improve reform measures, and deepen the integration of industry and education. This will strongly support the cultivation of high-quality professional degree postgraduates who can adapt to economic and social development and promote the coordinated development of education and industry.

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Disclosure statement

The authors declare no conflict of interest.

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The Protection of Academic Freedom by Leadership in the Process of Higher Education Modernization

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Abstract: The essence of academic freedom lies in scholars' autonomy in the pursuit of knowledge, free from external coercion and internal constraints, encompassing various aspects such as freedom of research, teaching, and learning. Leadership plays a crucial role in safeguarding academic freedom. Drawing on Macfarlane's conceptualization of intellectual leadership, this article examines faculty-based agency protection, as well as institutional, cultural, and resource-based protections at the university level.

Keywords: Higher education; Leadership; Academic freedom

Online publication: June 4, 2025

1. Introduction

Since the formation of higher education systems, institutional autonomy and academic freedom have been two core propositions, permeating all stages of higher education development and profoundly influencing its forms and quality^[1]. Current research on academic freedom, both domestically and internationally, is extensive, yet scholars exhibit significant divergence in their perspectives regarding its conceptual definition, essential components, inherent value, and boundaries. Philip G. Altbach asserts that "academic freedom means professors are free from external control in their professional fields, enjoying the right to teach freely and the freedom of student learning"^[2]. Other scholars have distilled academic freedom into four core issues: who teaches, what is taught, how it is taught, and who gets admitted^[3]. Academic freedom, as a privilege for university faculty, researchers, and learners^[4], carries multifaceted significance. On one hand, it minimizes the influence of external factors—such as administrative, capital, religious, and societal norms—on academic research and talent cultivation. On the other hand, it maximally stimulates the creativity of academic actors^[5]. Currently, China's higher education is undergoing modernization, with the national level placing high importance on academic freedom. Articles 35 and 51 of the Higher Education Law of the People's Republic of China stipulate

that “(universities) independently conduct academic research” and “provide favorable conditions for faculty’s academic research”^[6], providing legal safeguards for academic freedom. However, in practice, academic freedom faces multiple challenges, including excessive administrative interference in academic affairs such as discipline establishment, curriculum design, project approval, and professional title evaluation, significantly narrowing the space for academic decision-making^[7]. The prevalence of performance-oriented culture has distorted the academic evaluation system, pressuring faculty to choose “low-risk, high-output” research directions and exacerbating inequities in academic resource allocation^[8]. Furthermore, the involvement of capital and the infiltration of public opinion also impact academic freedom from various angles. Safeguarding academic freedom is an essential path to advancing higher education modernization, and leadership plays a crucial role in this protection. Leadership, as defined by White and colleagues’ research, refers to “a collective pattern where all members share leader influence within same-level or cross-level systems when addressing complex environments”^[9], its essence being the behavioral capacity for influence, change, and transaction between leaders and followers^[10]. Leadership’s protection of academic freedom manifests across multiple dimensions: agency-based, institutional, cultural, and resource-oriented.

2. Agency-based protection by university faculty

University faculty (professors) are both the subjects of academic freedom and the agents of its protection. In his 2012 publication *Intellectual Leadership in Higher Education: Renewing the Role of the University Professor*, Bruce Macfarlane argues that faculty play the role of intellectual leaders in modern higher education, and proposes four orientations of intellectual leadership: knowledge producers, academic citizens, boundary crossers, and public intellectuals—providing a comprehensive framework for faculty to safeguard academic freedom^[11]. From the perspective of knowledge producers, knowledge creation is faculty’s core responsibility, requiring them to maintain an innovative spirit, advancing disciplinary frontiers as their goal while consciously resisting utilitarian tendencies in knowledge production, ensuring the authenticity and originality of their work. As academic citizens—a legal concept combining rights with responsibilities—faculty enjoy academic freedom while bearing civic responsibilities, whose active fulfillment itself constitutes a vital aspect of protecting academic freedom. Currently, academic life is unprecedentedly close to social life, emphasizing application and collaboration between researchers and practitioners^[12]. Faculty must engage deeply in academic governance—from disciplinary development to societal impact—by actively participating in curriculum committees, journal peer reviews, and other services to defend academic norms against plagiarism, data fabrication, and similar misconduct, while fostering inclusive cultures within institutions to create favorable environments for knowledge production. From the perspective of boundary crossers, university teachers should transcend their own disciplinary backgrounds, break down academic barriers, and engage in interdisciplinary research to innovate knowledge production models. Industry-education integration is the only path to achieving high-quality development in higher education, encompassing three dimensions: macro, meso, and micro. At the macro level, industry-education integration refers to the integration of the two major systems—industry and higher education—by determining the direction of higher education development based on the current state and transformation trends of industry, and strengthening the role of higher education in serving industrial development. At the meso level, industry-education integration refers to the collaboration between key players in industry (enterprises) and higher education institutions. This involves bridging the gap between industry and education through school-enterprise cooperation, leveraging enterprise resources such as human resources, equipment, and facilities to optimize the talent cultivation mechanisms of universities, while also

enabling higher education institutions to contribute to enterprises in areas such as technological innovation and management reform. At the micro level, industry-education integration refers to the integration of production and teaching, embedding educational content into real production scenarios. By relying on a practice mechanism that combines theory and practice, it aims to cultivate students' practical skills and promote their professional development. Teachers should start from the role of higher education in modern societal development, act as a bridge for knowledge transformation, and promote the integration of industry, academia, government, and research. As public intellectuals, faculty combine quintessential intellectual traits—specialized expertise and academic rigor—with distinct “public” characteristics: actively engaging in public affairs, offering societal critiques, and upholding ethical convictions^[13]. As core members of the intelligentsia, faculty should evolve into public intellectuals by guiding values, democratizing knowledge dissemination, and critically engaging with social issues to steer societal progress.

3. Institutional, cultural, and resource-based protections by universities

Universities, as the arenas of academic life, bear the responsibility of safeguarding academic freedom and should strengthen their protection system through institutional, cultural, and resource-based dimensions. From an institutional protection perspective, the imbalance between academic and administrative power is a key factor enabling administrative violations of academic freedom^[14]. Clear boundaries must demarcate academic and administrative authority, delegating academic affairs—such as discipline/curriculum design, project approvals, and promotion reviews—to academic committees and other scholarly bodies, while administrative power focuses on macro-level oversight and support services^[15]. Concurrently, reforming evaluation mechanisms by implementing categorized assessment models—tailored to faculty's research orientations and scholarly aspirations—can help address these issues. Introducing diversified evaluation methods like “anonymous peer review” and “international expert assessment” can reduce administrative interference in evaluations, mitigating the negative impacts of publication- and grant-focused cultures on faculty^[16], thereby fostering an environment conducive to academic freedom through evaluation reforms. Teachers' participation in university governance is also an effective way to safeguard academic freedom. At present, China's higher education is undergoing a period of transformation and reform, which places higher demands on university administration and necessitates the involvement of teachers. From a macro perspective, university management is currently shifting from traditional bureaucratic administration to a flatter management structure. The management model is evolving from command and control to decentralization and consultation, with the central role of teachers in university governance becoming increasingly prominent^[17]. Therefore, from the perspective of modernizing the education governance system and governance capacity, it is essential to give full play to the role of teachers in university management. From a micro perspective, teachers are the core resource of universities and bear significant responsibilities. Whether it is program development, curriculum design, student cultivation, academic research, or university-enterprise collaboration, all these tasks rely on the work of teachers. Traditional management approaches are heavily characterized by administrative commands, often resulting in a disconnect between policy formulation, implementation, and supervision. This not only undermines the effectiveness of policy execution but can also dampen teachers' enthusiasm, weaken their sense of belonging, and ultimately contribute to talent loss. Therefore, strengthening teacher participation has become an objective necessity for optimizing university management. From a cultural protection standpoint, university culture—formed through long-term institutional practices with distinct characteristics—represents a core component of academic leadership^[18]. Leaders should

fully recognize academic freedom's significance by participating equally in scholarly activities as peers, establishing positive modeling effects within institutions, while actively promoting academic communities through initiatives like scholarly salons and interdisciplinary workshops to internalize the values of academic freedom ^[19]. In his book *Community and Society*, German sociologist Ferdinand Tönnies juxtaposed the concepts of community and society, arguing that society reflects accidental and transient relationships among people, while community represents “enduring relationships between individuals,” thus initiating the study of communities. Building a new teacher community is not only an objective need for the overall professional development of new teachers, but also an essential requirement for safeguarding academic freedom. In this regard, professional collaboration should be regarded as an important approach to teachers' professional development, and by relying on teacher communities, a positive culture that upholds academic freedom should be fostered within the teaching staff and throughout the school. Academic freedom is not purely an imported concept; it also carries deep historical roots and traditional cultural foundations in China ^[20]. The development and application of traditional culture should be strengthened to leverage its value-guiding role in academic freedom. From a resource-based protection perspective, academic freedom relies on material safeguards, particularly funding. Sufficient financial support enables faculty to maintain independence free from external dependencies. The financial autonomy of colleges and universities should be further expanded, and a financial support mechanism integrating multiple channels, such as fiscal appropriations, social donations (without additional conditions), and school-established funds, should be established. Enable teachers to choose research directions and carry out knowledge production according to their own will. The Education Informatization 2.0 Action Plan issued by the Ministry of Education in 2018 ^[21] emphasizes the “core concept of deep integration of information technology with education and teaching,” marking not only a new stage in the development of education informatization but also placing higher demands on mathematics education. Digital technology holds vast potential for application in education and teaching, and each breakthrough in digital technology drives the creative development of educational practices. At present, digital technologies such as big data, virtual reality, blockchain, and artificial intelligence are unleashing tremendous vitality. The application of digital technology should be regarded as an important means to promote resource sharing, facilitate collaborative academic research, and safeguard academic freedom, thereby accelerating the informatization of schools.

4. Conclusion

The protection of academic freedom is the inevitable path for higher education to move towards modernization. In this regard, we should start from the two levels of teachers and universities, with leadership as the core. An academic freedom protection system covering subjective protection, institutional protection, cultural protection, and resource-based protection should be built.

Disclosure statement

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From Children to Society: A Brief Comparison of Chinese and Korean Music Education

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Abstract: As a unique form of education, music education influences individuals' thoughts, emotions, and overall qualities through the medium of music. It has become an indispensable component of modern educational systems. Whether viewed broadly as an art form that enhances individuals' aesthetic, moral, and humanistic literacy, or narrowly as systematic instruction within school settings, music education plays a crucial role in students' holistic development. It not only cultivates musical literacy but also promotes intellectual, emotional, and social growth. Thus, music education holds significant social and cultural value in fostering creativity, inspiring emotions, and shaping character.

Keywords: Music education; China-Korea music education differences; School music education; Social music education; Social function

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1. Introduction

Society keeps moving forward, and globalization speeds up. Different countries show various features and advantages. This is true for children's music education and social music education. China and the Republic of Korea have different cultures and education systems. When carrying out music education, they have developed different models, goals, and methods. In recent years, China has reformed its music education gradually, but the process still has many problems. Curriculum design, teacher quality, and teaching methods are involved. These aspects are still not as good as the world's best practices. The Republic of Korea's music education system, on the other hand, focuses on cultivating children's interest and creativity in music from a young age. It actively encourages music education to spread across all levels of society. Special attention is paid to protecting and developing traditional music.

This paper looks at how China and the Republic of Korea are alike and different. The focus is on children's music education and social music education. It analyzes their educational aims, teaching methods, curriculum setups, teaching activities, and teacher resources. It studies the Republic of Korea's successful experiences. It also explores possible changes for music education development in China. The hope is that soon, the quality of

music education in China can improve. Then music can play an important part in training all-round talents for the new era.

2. The concept of music education

Music education is an educational activity. It uses the art of music. It has a deep impact on people's thoughts, feelings, and cognitive abilities. It helps people gain knowledge and improve skills. Music education is not just about school-based education in the traditional sense. It includes many forms, including family education and community-based education. This shows how widely and diversely music exists in society. Through music education, individuals not only acquire professional musical skills but also achieve comprehensive development in emotional, cognitive, and social dimensions, thus promoting overall personal growth. Music education can be categorized into two levels: broad and narrow, each with distinct characteristics and functions.

2.1. Broad music education

This refers to all educational activities that impact various aspects of an individual through musical experiences. It goes beyond training in musical skills to include artistic, moral, and ideological education achieved through music. Broad music education emphasizes not only the cultivation of musical skills but also the shaping of emotions, aesthetic appreciation, moral values, and humanistic qualities through music. It aims to develop individuals with rich cultural depth and spiritual awareness by fostering their perception of beauty, pursuit of goodness, and exploration of truth. Ultimately, it enables individuals to comprehend the world and shape their personalities at a higher level, becoming well-rounded members of society ^[1].

2.2. Narrow music education

This specifically refers to music education conducted within structured educational environments and under defined conditions, organized according to societal needs, with explicit goals and plans—namely, school-based music education. This form of education occurs across all levels of the formal education system, including preschool, primary, secondary, higher, and adult education. Compared with the diversity and flexibility of broad music education, narrow music education focuses more on providing systematic and standardized music instruction in school settings. It aims to cultivate students' professional competence in music and mastery of musical skills. Students not only learn basic skills such as performance and composition but also receive training in music theory, aural skills, and sight-singing, which deepens their understanding of musical structure and expressive techniques.

Music education matters for students' all-round growth. It boosts musical skills and helps with intelligence, emotional skills, and social skills. When students create, perform, or enjoy music, they express feelings, build good personalities, and learn to manage emotions. Plus, music education strengthens memory, focus, and creativity. Learning music is not just about getting technical skills. It changes how students think, understand, and express emotions, promoting growth in many ways. In short, music education is a multi-faceted teaching method. Using music as a special tool, it develops musical talent and promotes growth in emotions, thinking, and social skills. Its importance extends beyond classroom learning. Music education greatly helps improve students' overall abilities, encourages creative thinking, and expands emotional expression. As a type of cultural education, it is crucial for building a country's cultural soft power and for passing on and innovating traditional culture. Improving music education can train more people with good musical skills and artistic awareness. This can push society and culture forward and make them thrive.

3. Comparison of music education for children in China and the Republic of Korea

3.1. Educational objectives

3.1.1. China

In the preschool stage, Chinese music education focuses on cultivating children's basic appreciation of music, stimulating their interest in perceiving beauty and enjoying artistic activities, and encouraging them to express art in their preferred ways. At this stage, the emphasis is on sensory experience and nurturing an interest in art through singing, dancing, games, and simple creative activities to develop an initial understanding and recognition of the arts. However, in some kindergartens, these objectives are not fully realized, especially in the area of "artistic expression." Problems such as uneven distribution of teaching resources, insufficient qualified teachers, and monotonous content hinder children's development in expressive abilities.

As students enter primary and secondary school, the revision of the "Guidelines for Music Education" in 2011 marked a shift in focus toward the "humanistic," "aesthetic," and "practical" dimensions of music education. While maintaining traditional elements, greater emphasis is now placed on cultivating emotional sensitivity, attitudes, and values through music. The aim is not just technical training anymore. Now, it centers on emotional connection, aesthetic feeling, and artistic knowledge. It tries to develop students' humanistic attitude and social responsibility. Nonetheless, many schools still face practical challenges, such as limited resources and an exam-oriented curriculum, which hinder the effective implementation of these goals ^[2].

3.1.2. The Republic of Korea

When compared with China, the Republic of Korea's preschool music education puts more stress on using the arts to discover the beauty of nature and the environment. Children are urged to use different ways such as singing, dancing, and painting to show how they understand and feel about art ^[3]. The focus is not solely on music itself, but on self-exploration, the development of innovative thinking, and artistic expression.

Also, the Republic of Korea's educational idea focuses on overall growth. Preschool education wants to do more than teach musical skills. It also wants to develop creativity and good character. By taking part in different art activities, children improve their imagination, creative ability, and emotional understanding. This gives them a strong base for future social life. China's model often focuses more on professional talent. In contrast, the Republic of Korea gives importance to making music education social and widely available. The goal is to make music part of daily life. It helps children build cultural knowledge and overall abilities through music learning ^[4].

Thus, the Republic of Korea's music education goals are not just about training professionals. They focus on overall development, new ideas, and being able to fit into society. Music helps children develop their personalities, express their feelings, and learn social skills. It is an important part of childhood education.

3.2. Teaching approaches

In China, traditional music teaching methods usually stick to strict and set teaching steps. Teaching from textbooks and doing beat-training exercises are common. Lots of teachers put a lot of emphasis on teaching theory and doing technical practice. Their aim is to make sure students learn basic music theory and performance skills well. However, this approach tends to neglect student interest and creativity, leading to monotonous and disengaging classroom environments. For young children in preschool, long periods of theoretical teaching and skill-focused drills are usually not interesting. This makes them less enthusiastic and

less likely to take the initiative ^[5].

With evolving educational philosophies, more schools are adopting innovative ways. Learning based on contexts and projects has been showing up more often in classrooms. These methods create learning environments that draw children in. In these settings, kids explore and find out the appeal of music through real-life situations. Also, schools are making their music courses more varied. They are adding different types of music, like choral singing, dancing, and percussion. This enables students to have a more lively and interesting experience of music.

On the other hand, the Republic of Korea's teaching method has "play" at its core. Music education is provided in a laid-back and pleasant environment. It encourages children to learn by taking part in games and fun activities. Music is seen as something new and fascinating, not just as a skill that needs to be acquired. This greatly lessens the pressure on children. It enables them to freely enjoy, sense, and experience music. As a result, it cultivates a true interest in and love for music.

Music classes in the Republic of Korea are highly interactive. Children take part in singing, dancing, and playing musical instruments. They use a lot of imagination and creativity while doing these activities. Teachers employ games, role-playing, and performances. By doing so, they actively involve the students. This helps in improving the students' aesthetic sensitivity and their ability to express emotions. Music is closely connected to daily life. It does not just stay within the classroom. Instead, it turns into a vital part of children's development.

This method does not just develop children's love and enthusiasm for music. It also helps with their all-round development. This includes expressing emotions, interacting socially, improving motor skills, and fostering creativity. Different from the models that focus on exams, the Republic of Korea's music education, which centers on children, gives importance to their individual growth. Its goal is to assist every child in discovering the joy and value in music. It also builds a solid base for their future development.

3.3. Curriculum design

In terms of curriculum design, while China's preschool education includes designated music textbooks, these materials often present several issues, such as being outdated, lacking innovation, and offering insufficient aesthetic appeal. As a result, the attractiveness and effectiveness of music education are significantly diminished. Many of these materials emphasize basic technical training, neglecting the artistic and emotional dimensions of music, which makes it difficult to stimulate young children's interest. Consequently, the process of learning music can become dull and uninspiring.

At the primary and secondary school levels, although music is a required subject under compulsory education, in practice, music classes are frequently replaced by core academic subjects. Many schools do not assign sufficient importance to music education, resulting in inadequate scheduling and implementation. Furthermore, most music curricula are heavily skewed toward Western music, especially in areas such as theory and vocal training. Classical Western works dominate teaching resources, while local traditional music is significantly underrepresented. Although recent years have seen some attempts to incorporate national cultural elements, overall, the music curriculum remains predominantly Western, lacking both cultural diversity and comprehensiveness ^[6].

In contrast, the Republic of Korea does not employ a unified national textbook for preschool music education. Instead, teachers independently design lesson plans based on the themes and objectives of each academic term. This flexibility allows for curricula to be tailored to students' interests and developmental needs, as well as to incorporate seasonal, festive, or contemporary cultural elements. Educators often select melodically

rich and engaging songs or nursery rhymes that capture children's attention and foster a love for music.

Moreover, from kindergarten through secondary education, the Republic of Korea places strong emphasis on traditional music education. Regardless of the stage, traditional music is an integral part of the curriculum. Education policies explicitly define traditional music education as a key aspect of cultural heritage transmission. Children are introduced to and taught native musical forms from an early age, fostering both musical literacy and a deep sense of cultural identity and pride. This educational design supports students' understanding of diverse musical traditions while promoting the preservation and continuation of national culture.

3.4. Teaching practice

In some Chinese music classrooms, teaching practices often overemphasize discipline management and knowledge transmission. Teachers tend to focus excessively on students' memorization and comprehension of textbook content, neglecting the cultivation of improvisational ability and creative expression. This skill-centric, standardized teaching model can lead to dull classroom experiences, reducing student engagement and motivation. Additionally, many parents regard music learning as a utilitarian tool, often aimed at earning extra points in entrance examinations or enhancing academic competitiveness^[7]. This instrumental approach has contributed to the exam-oriented nature of music education, where the core purpose of cultivating musical sensitivity and creativity is frequently overlooked.

Although some schools and educators have begun recognizing this issue and are exploring more innovative teaching methods, the overall educational philosophy and practices still require further improvement and reform.

In contrast, the Republic of Korea places a strong emphasis on innovation and interaction in its music education practices, particularly in early childhood education. Preschool music classes in Korea integrate singing, dance, and other artistic forms to create a lively and engaging environment. Within this joyful atmosphere, children are encouraged to perceive and express music through multisensory experiences. This approach not only improves their technical skills but also allows them to freely unleash their creativity, fostering both musical interest and aesthetic sensibility.

Moreover, music education enjoys a high level of societal recognition in Korea. Many families actively support their children's musical development by providing ample resources. Children are often introduced to a variety of musical instruments or receive vocal training, which helps them fully explore their musical talents and potential^[8]. The Republic of Korea's educational philosophy and its supportive social environment thus provide a broader platform for musical learning, enabling children to grow and thrive in an enjoyable and expressive musical journey.

3.5. Teaching faculty

The overall quality of teaching faculty in China's early childhood music education sector is uneven. Some educators lack an in-depth understanding of the developmental characteristics and pedagogical principles specific to young learners. Teaching methods are often simplistic and repetitive. In recent years, due to the rising demand for music education, individuals without professional backgrounds have entered the field, leading to a mixed and inconsistent teaching workforce.

On the contrary, the Republic of Korea has a music teaching staff that is of relatively high quality and well-trained. These teachers not only show great professional knowledge and skills. They also attach importance to research and innovation in teaching methods. Music colleges in Korea set rigorous standards for prospective

educators, often requiring demonstrable academic achievements to ensure the quality of instruction.

At present, China's music education for children still has a lot of room to improve. More attention needs to be paid to developing children's creativity and helping them become well-rounded. Teaching methods should focus on getting students involved and having hands-on learning experiences. This will increase students' participation in music classes. Making children the main focus of teaching can help cultivate their real interest in music.

For curriculum design, we need to do more to combine traditional Chinese music better and update textbook content so it matches modern developments. When it comes to teacher training, it is crucial to raise educators' professional standards and their ability to innovate in teaching methods. Opportunities for exchange and collaboration with outstanding domestic and international educators should be actively pursued in order to absorb best practices and refine instructional content.

Government departments, schools, teachers, and parents all have to cooperate with each other to move forward children's music education in China. When they do this, music can turn into a more influential and fulfilling part of children's growth process. It can help in bringing up people who are well-developed and have a good sense of aesthetics.

4. Comparison of social music education in China and the Republic of Korea

4.1. Concept of social music education

Social music education refers to musical education activities that extend beyond the realm of formal school instruction and are directed at a broad social demographic. This form of education includes not only traditional classroom-based learning but also music-related instruction within families, community activities, programs organized by cultural institutions, and various music events led by social organizations. The core objective of social music education is to enhance cultural literacy, emotional expression, and social capabilities—both at the individual and collective level—while fostering a sense of social responsibility.

The fundamental goals of social music education are to provide wider access to music learning opportunities and to support the overall development of participants^[9]. While imparting theoretical knowledge and technical skills, it also focuses on cultivating aesthetic awareness and emotional intelligence.

The key characteristics of social music education include:

- (1) Universal accessibility: Unlike traditional school-based music education, social music education targets all segments of society. Regardless of age—children, adolescents, adults, or the elderly—and regardless of social status, everyone is eligible to participate. This inclusiveness promotes musical engagement across diverse demographics, fostering shared interests and communal identity while enhancing social inclusivity and diversity.
- (2) Diversity and flexibility: Social music education encompasses a wide variety of formats, such as community choirs, music interest groups, music therapy, and online music courses. These programs are not bound by conventional classrooms or rigid methodologies; instead, they emphasize learners' interests, interactivity, and experiential learning. For example, community music events prioritize group participation and communication, while online programs break down temporal and geographic barriers, allowing individuals to study music at their convenience^[10].
- (3) Cultural and emotional functions: Beyond technical training, social music education serves as a powerful medium for emotional expression and cultural identity. Through learning and performance,

participants develop a deeper understanding of their own emotions. Music's inherent ability to transcend language and geography allows it to act as a bridge between cultures. Collective performance activities, such as ensemble playing or choral singing, help strengthen community cohesion, promote cultural exchange, and enhance aesthetic taste and cultural appreciation.

- (4) Social integration and public service: Social music education facilitates social integration, particularly in multicultural societies. It provides a platform for individuals of different cultures, backgrounds, age groups, and social classes to interact and collaborate. Music education fosters empathy, mutual understanding, and communication, helping reduce societal divides and encouraging cooperation. It contributes to social harmony and supports sustainable social development.

As a broad-based educational model, social music education not only teaches musical skills but also emphasizes emotional connection and social interaction. Through engagement in such programs, individuals and communities alike benefit from enhanced emotional well-being, richer cultural experiences, and stronger social cohesion.

4.2. Comparative analysis of social music education in China and the Republic of Korea

Firstly, regarding the degree of popularization, social music education in the Republic of Korea enjoys a high level of engagement. Approximately two-thirds of children participate in some form of music education. Some families get private teachers to teach. Other families use free classes from churches or community groups. Kids in Korea often join various performance events when they are young. Korea's music education at first aims to help students understand theory better. It also works to boost their overall skills. It helps ease school stress and lets them show their feelings. To a lot of Koreans, music is not just about learning. It is a way to have fun and is a big part of their everyday life.

In addition, as a country that places great emphasis on national pride, the Republic of Korea actively protects and promotes traditional music culture, ensuring its deep roots in society. Starting from kindergarten, kids learn traditional music. Many special schools have early music teaching plans. These plans want to pass on and keep cultural traditions ^[11].

In China, it is different. Social music education is mainly an additional cultural learning. Some parents see it as a chance to live out the dreams they could not achieve as kids. Other parents want their children to develop interests or learn to interact with others through music. However, there is also a significant number of parents who focus on quantifiable outcomes such as examination certificates—seeking recognition and achievement through comparisons with peers—rather than emphasizing musical cognition or aesthetic development. Additionally, many parents consider music education a stepping stone toward university admission via art-track examinations, aiming to gain admission to prestigious institutions through special talent recruitment programs.

As music certificate exams have gradually become part of the evaluation system for high school and college admissions, an unhealthy trend of competition has emerged in social music education. This has led to a distortion of its original purpose.

Although China has also made efforts to protect and promote traditional music, policy support and public awareness remain insufficient. While calls for the preservation of traditional music are widespread, effective implementation is still lacking. As a result, society has yet to fully recognize the importance of traditional music and music education more broadly. To fix this, we really need to help people understand better how valuable traditional music is for culture and education. We should get more support from institutions. We can also look at what the Republic of Korea did right in social and traditional music education. This can make music education

in China easier for people to access and help it fit better into our culture.

4.3. Qualifications of social music educators

In the Republic of Korea, the requirements for social music teachers, especially those in teaching or professor jobs, are very strict. People who apply have to give detailed resumes, lists of the academic papers they have written, and their research results. Often, applicants also need to have studied music in another country or they need to be well-known people or leaders in the music field. After professors get the job, they must show their qualifications, what they have achieved in academics, and what they specialize in. This helps students choose courses, knowing all the facts. When students drop a course or lacking students, the course gets canceled. Then, the professor might lose their job. Also, at the end of every semester, students rate their teachers on the internet. These ratings help check how well teachers are doing their jobs.

Even within private social music training institutions, instructors often hold master's or doctoral degrees from prestigious international conservatories. This strict standard makes Korean music education match what is done around the world. It makes sure music teachers reach a certain professional level. This creates a good setting for music education. It also helps raise the musical knowledge and sense of beauty of everyone in society.

China is different, there are big differences in the skills of social music teachers. Lots of teachers do not have enough experience. Also, the quality of teaching, the ways of teaching, and the academic rules are different everywhere. Many institutions do not hire professionals who graduated from good music colleges or conservatories. Instead, they choose people who majored in education at teacher-training universities. Even if these people are not as good at teaching and performing as other, more qualified applicants.

Plus, China lacks a clear system for certifying and overseeing social music education. Many people who taught themselves and have no proper training have started their own private studios or schools. Because of this, there are a lot of low-quality music training places. These problems stop social music education from growing well and need to be fixed right away.

China is huge with a large population. Getting most of the teaching staff to have master's or doctoral degrees from foreign schools is hard. It will take a long time to make this happen. To deal with this, the country needs to build better infrastructure and raise living standards. This way, young people can get more chances to study. Meanwhile, it is important to help children develop a strong sense of cultural identity and a dedication to education from a young age. This can make sure that students who study overseas have the ability and the will to use their knowledge and skills to help their home country.

4.4. Performance culture in social music education

The Republic of Korea has a very good social music culture. In big cities, there are many places to perform. There are big theaters and small community stages. All these places have professional music gear and workers. They make sure the shows are good. Even in smaller cities, music lighting systems and audio-visual technicians are readily available. Furthermore, ticket prices span a wide range—including affordable options—making it feasible for the public to regularly attend performances. This accessibility allows Korean citizens to experience live music from a young age, nurturing an early appreciation for the art form and fostering a vibrant performance culture.

In such a social environment, music becomes an indispensable part of personal growth. Participation in musical performances, both as audiences and performers, subtly enhances the population's artistic sensibility, cultural literacy, and aesthetic understanding. Music education is thus not limited to formal instruction—it

becomes embedded in everyday life, contributing meaningfully to the cultivation of national aesthetic values and overall social harmony.

While China also places considerable value on social music, most performance venues are concentrated in first-tier cities. In second- and lower-tier cities, limitations in policy support and funding result in a relative scarcity of music theaters, professional-grade equipment, and service personnel. Consequently, the spread and accessibility of music performance experiences are limited.

Ticket prices for performances in China have also risen significantly in recent years. Affordable tickets—once available for as low as several dozen yuan—have become increasingly rare. In many cases, the lowest ticket prices now exceed 100 RMB, with no clear upper limit. Moreover, audiences for music performances in China are still largely composed of performers, educators, students, or dedicated enthusiasts. True popular participation remains limited, and the notion of “music for all” has yet to be fully realized.

5. Recommendations for improving music education in China

First and foremost, national and local governments, along with higher education institutions, should elevate their recognition of the function and significance of social music education. This can be achieved by optimizing macro-level policies, establishing clear evaluation standards, supporting training institutions, defining qualifications for operation, strengthening regulatory oversight, and implementing reasonable pricing structures. These measures would help establish education providers that meet actual societal needs and promote the balanced development of social music education across regions. Local governments, in particular, can make better use of resources from universities, art troupes, and performance venues by publicly recruiting and supporting projects focused on intangible cultural heritage with distinctive ethnic features. This would provide platforms for traditional artists to perform, contribute to the dissemination and revitalization of traditional music, and support the inheritance of national cultural identity. Besides, adding various performance styles can liven up local cultural activities. It can improve how the public enjoys art. It can also help social music education spread more widely.

Next, we should create qualification and assessment rules for music teachers. These rules should match the features of social music education. We can base them on the current teacher certification systems used in schools. We have to create a good system for hiring and assessing music teachers. This system will boost the professional skills and teaching abilities of music educators. As a result, it will raise the quality and trustworthiness of social music teaching. Meanwhile, teaching methods ought to concentrate on building students’ interest. They should also build a strong base in music theory, improve students’ aesthetic judgment, and encourage creative ability. Students should be encouraged to discover and create beauty through music. Music assessment systems, especially music grading exams, should be reformed starting from the foundation of general education. This includes diversifying instructional content, organizing public performances, and optimizing evaluation methods to move beyond rigid and standardized formats. Ultimately, the aim is to guide learning motivation appropriately and implement people-centered education that fosters well-being through meaningful musical experiences.

Thirdly, China should actively draw on successful international experiences in social music education while tailoring strategies to its own national context. Research should be conducted to develop age-appropriate, culturally relevant pedagogical theories and methodologies for music instruction. Traditional music grading materials must break away from outdated models and keep pace with the times through continual innovation,

ensuring that social music education evolves in a healthy and sustainable direction. Furthermore, efforts must be made to broaden access to music education. Music should become a vehicle for emotional connection, moral cultivation, spiritual enrichment, and community cohesion. Through the moral and cultural functions of music education, the comprehensive quality of the general population can be significantly improved.

By analyzing both children's music education and social music education, it is evident that with the ongoing development of politics, economy, and culture—and the corresponding improvement in material and spiritual well-being—music is gradually becoming an integral and sustainable component of society, everyday life, and education. As a prevailing educational trend, it is of far-reaching importance to understand the similarities and differences between China and the Republic of Korea in social music education, learn from other countries' successful practices, and develop a uniquely Chinese model of social music education that enhances aesthetic literacy and contributes to the all-round development of children.

Disclosure statement

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The Significance of Teacher-Training Education in the Cultivation of Clinical Competence and Academic Literacy of Academic Postgraduates in Chinese Medicine

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Abstract: As a core mechanism for training talents in Chinese medicine, a follow-up study has constructed a unique Chinese medicine education model through the in-depth intermingling of teacher-training mode and clinical practice. In the process of teacher training, the tutor transfers the implicit knowledge such as identification thinking and medication experience in the form of “oral transmission and clinical instruction,” so that the academic postgraduates of Chinese medicine can understand the holistic view of the correspondence between heaven and man, the methodology of identification and treatment, and the internal logic of rationale, methodology, prescription and medicine in the clinical diagnosis and treatment. This kind of transmission not only strengthens the students’ basic clinical skills of combining the four diagnoses and analyzing the evidence, but also fosters their academic innovation ability of applying classical theories to solve complex clinical problems through the in-depth analysis of typical medical cases. In this paper, we discuss the significance of teacher-training education in the training of academic postgraduates in Chinese medicine, and propose an optimization path for the reference of higher education in Chinese medicine.

Keywords: Teacher training; Chinese medicine education; Follow-up study; Academic postgraduate students of Chinese medicine; Clinical practice of Chinese medicine

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1. Introduction

Since ancient times, Chinese medicine has taken the “teacher-training system” as the core inheritance mode, and the question and answer between Qibo and Huangdi in the *Yellow Emperor’s Classic of Internal Medicine* embodies the teaching characteristic of “teaching by word of mouth and heart.” As one of the main methods to cultivate Chinese medicine talents, teacher-training education is generally inherited by the family and

masters, and the medical theories and clinical experiences of famous doctors are passed down from generation to generation through learning by ear^[1], and famous doctors of the past generations have accumulated clinical experiences by following the masters to form the unique thinking of the masters in the identification of evidence and the use of medicines in the clinical practice. Teachers follow the study to teach the theoretical knowledge of Chinese medicine and emphasize clinical practice and medical ethics, and cultivate students' evidence-based thinking by teaching them by example and listening to them, which has the advantage of teaching students according to their aptitude^[2,3]. However, the current training model for academic degree students in Chinese medicine places a strong emphasis on scientific research and experimentation, while clinical competence is not included among the core assessment criteria. Over time, this inevitably leads to the neglect of clinical practice, resulting in the awkward situation where academic postgraduates “only conduct experiments but do not see patients.” The practice of following a teacher in clinical settings can help address this shortcoming by enabling students to balance both clinical practice and scientific research. Since academic postgraduates do not participate in standardized residency training, they can allocate time for clinical observation and practice alongside their research activities. Therefore, it is recommended that academic postgraduates engage in clinical practice early on, integrating theoretical research with clinical experience. By emulating their mentors' traditional diagnostic and treatment approaches, students can cultivate clinical diagnostic thinking in Chinese medicine. This not only enables them to identify problems arising from clinical practice but also allows them to apply modern scientific methods and technologies to conduct innovative research^[4]. This paper analyzes and summarizes the significance of teacher-guided clinical training in enhancing both the clinical competence and academic literacy of postgraduate students in Chinese medicine, as outlined below.

2. Bridging the gap between theory and practice

At present, postgraduate education in Chinese medicine is mostly based on university education, aiming at cultivating high-quality Chinese medicine talents with “broad knowledge, thick foundation, strong ability and high quality,” so as to ensure the cultivation of Chinese medicine talents with systematic and professional knowledge of Chinese medicine theories and skills^[5]. With the popularity of institutional education, the traditional teacher-training system has been gradually replaced by standardized curricula, but the disadvantage of “focusing on theory but not practice” has been highlighted. Modern traditional Chinese medicine (TCM) education needs to “return to the essence of teacher-training” and restore the clinical thinking training of “teacher-training” through follow-up learning. As a bridge connecting TCM theory and clinical practice, it has become an important means to make up for the insufficiency of education in colleges and universities. There is a tendency to “focus on theory but not practice” in Chinese medicine education. Institutional education focuses on the teaching of classical theories, while follow-up learning can transform abstract knowledge into concrete clinical skills. Clinical scenarios are the best environment for knowledge internalization. By observing the actual operation of pulse diagnosis, tongue diagnosis, and other diagnostic techniques by the teacher, students can break through the textual limitations of the books and master clinical diagnostic skills.

3. Better grasp of research directions

Academic postgraduates need to take into account both scientific research ability and clinical skills training in TCM, but in the current training mode, the two are often separated: for academic postgraduates, their research direction is mostly focused on molecular biology and other basic areas of research, and the problem

orientation is often out of touch with the actual clinical problems; and for professional postgraduates, most of their time is spent on clinical rotation, which results in a lack of long-term and systematic targeted training of scientific research ability, making it more difficult to produce high-quality research results. For professional postgraduates, most of their time is spent on clinical rotations, thus lacking long-term, systematic, and targeted training in scientific research ability, and it is more difficult to produce high-quality research results. According to the current research, the scientific problems of academic postgraduates in TCM are less relevant to clinical practice, less innovative, and provide little guidance to clinical problems ^[6]. Western medicine helps to achieve the integration of clinical and scientific research through the “clinical rotation-scientific feedback” model (e.g., “problem-oriented learning”). TCM followers can learn from this model and build a closed loop of “clinical problem-scientific research-clinical application” to drive high-quality research topics with clinical problems. Clinical reflection is the core of thinking improvement, and “follow the teacher–perception–innovation” is the three-step path of TCM inheritance. From the typical cases or difficult cases observed in the follow-up consultation (e.g. chronic gastritis, systemic lupus erythematosus, etc.), we can think about why the diseases are cured or recurring, and even refine scientific questions from the clinical phenomena that are difficult to overcome in the process of the occurrence and development of certain diseases. Academic inheritance is the driving force of clinical, scientific research, and talent cultivation. Professor Wang Qiaochu, a national famous veteran Chinese medicine practitioner, put forward the idea of Chinese medicine research on “empirical prescription drugs–clinical research–drug coarse screening–clinical re-study–pharmacodynamics, pharmacological research–preparation development–transformation of the results,” which provides inspiration for his students to make innovations in the field of new Chinese medicine research ^[7]. Based on the evaluation of the efficacy of follow-up cases (e.g., the clinical efficacy study on the treatment of a certain disease by a prescription drug), we explore the research mechanism of the action of the prescription drug on the disease, find out the problems from the clinical practice of Chinese medicine, and rethink the existing clinical interpretations through the in-depth study of the scientific research and the application of the research results, so as to further enhance the clinical ability of the physicians, improve the clinical efficacy, and cultivate the talents with the ability of innovation for the benefit of the patients and the society ^[8].

4. Inheriting the experience and academic characteristics of famous doctors

Chinese medicine has been inherited for thousands of years because of the excellent traditional thought of continuous inheritance and development. Only by doing a good job of inheritance can we maintain the characteristics and advantages of Chinese medicine, and only on the basis of inheritance can we realize the innovation and development ^[9]. Follow-up is the core carrier of Chinese medicine experience inheritance, and the education of famous and old Chinese medicine teachers is a kind of teaching method to inherit the clinical experience and academic development ideas of famous and old Chinese medicine experts, and its purpose is to inherit the diagnostic thinking method and academic research characteristics of famous and old Chinese medicine experts. Learning from famous and veteran Chinese medicine experts in the process of understanding the thinking process of evidence identification and treatment, and its speculation, understanding, and summary, can deeply comprehend the essence of their academic, through long-term exposure to the unique charm of Chinese medicine knowledge, which is difficult to be presented in the classroom ^[10]. Beijing University of Chinese Medicine integrates the national teacher succession work with undergraduate training, postgraduate training, and young teachers’ training work, and effectively improves the quality of students’ and young

teachers' training through outpatient clinics to follow famous doctors, salons to learn the path of growth of famous doctors, reading and feeling the classics of Chinese medicine, regular academic lectures on the topic of famous doctors, and wards to assess the competition of classic diagnostic and treatment programs of famous doctors, etc., and makes full use of the advantages of the academic experience inheritance work of the national veteran Chinese medicine experts. The advantages of the academic experience inheritance work of Chinese medicine experts have laid a solid foundation for the training of famous doctors ^[11].

5. Cultivating clinical thinking patterns in Chinese medicine

During the follow-up process, students copy the prescription to follow the consultation process. Through the patient's four diagnosis, the teacher's experience with medication and the patient's medication feedback from a large number of records and learning and thinking, has accumulated a wealth of theoretical knowledge and clinical experience. In the process of constantly following the teacher, students gradually establish their own diagnostic and therapeutic ideas and discursive thinking ^[12]. Some research results show that the clinical thinking and discursive ability of the students who learnt from their teachers is significantly higher than that of the students who did not learn from their teachers in a systematic way ^[13], which is mainly manifested in the following points: firstly, the students need to observe in the clinic how their teachers integrate the information from the four diagnostic examinations into the conclusion of the diagnosis, and to learn the logic of the overall view of Chinese medicine and other clinical decision-making, which will subconsciously deepen their understanding of the holistic view of Chinese medicine. Secondly, when these students learn from the teacher's diagnostic and treatment ideas, prescription and drug delivery experience, they often avoid pure imitation and integrate independent thinking and innovation, improve their own knowledge structure, form their own diagnostic and treatment ideas, and organize, condense and improve what they have learnt from the clinic, so that they can rise to the level of academic thinking. The academic experience is embedded in daily life, and the ability of literature search and essay writing is enhanced, so that the academic ideas and the experience of using technology can be used to form academic essays, academic works, or to improve the quality of scientific research ^[14].

6. Enhancing the ability to handle complex cases

Postgraduate students in outpatient clinics will be the first contact with real patient groups, requiring physicians to make rapid judgments on the patient's situation, and based on this rational use of medication, students' clinical ability can be developed in this process ^[15]. Students follow their teachers to study cases of different types and complexity, encountering combinations of symptoms and identification difficulties rarely seen in textbooks, and through observing their teachers' diagnosis, analysis, and treatment of different conditions, they can gradually familiarize themselves with the manifestations, developmental changes, and treatments of various diseases, and accumulate rich clinical experience. In-depth analysis and discussion and differential diagnosis of similar diseases under the guidance of the teacher can provide a deeper understanding of the nature of the disease and the key points of diagnosis and treatment, which helps to develop one's ability to analyze and judge complex cases, avoid one-sided or wrong diagnosis, broaden clinical thinking, and improve the ability to accurately diagnose complex cases. For complex cases, the treatment plan usually needs to take into account a variety of factors, such as the patient's age, underlying diseases, and the severity of the disease. During the follow-up consultation, students can learn from the teacher how to formulate personalized treatment plans

according to the patient's specific conditions, including the selection of drugs, adjustment of dosage, and the timing of treatment, so as to improve their ability to formulate reasonable treatment plans.

7. Adapting to the development trend of modern Chinese medicine education

The Chinese Medicine Development Plan for the 14th Five-Year Plan issued by the General Office of the State Council of the People's Republic of China explicitly proposes to "improve the education system of teacher training in Chinese medicine, and promote the organic convergence of teacher training with institutional education, post-graduation education, and continuing education." In recent years, China's colleges and universities of traditional Chinese medicine have actively responded to the national development plan for traditional Chinese medicine, followed the laws of the development of traditional Chinese medicine education, and explored and practiced a variety of modes of teacher education. Taking the pilot class as the main focus, combining with the actual situation of their respective institutions, they have innovated the mode and form of teacher-training education, and carried out the reform and practice of integrating with the education of the institutions. The general basis of the reform is to supplement the teacher-training education without changing the basic mode of the existing education of the institutions, and to give full play to the characteristics and advantages of the teacher-training education of Chinese medicine, with the goal of cultivating the students' thinking of traditional Chinese medicine and clinical diagnosis and treatment ability.

Beijing University of Traditional Chinese Medicine (BUTM) has set up a five-year experimental class combining the three modes of education in Chinese medicine, namely, "institutional, teacher-training, and family-training," and has formed an on-campus "basic course stage clinical apprenticeship + clinical apprenticeship with teachers" and an off-campus "winter and summer holidays study with teachers." Clinical apprenticeship in the basic course stage and off-campus "learning from teachers during summer and winter holidays" are formed ^[16]. For example, "Tietao class," "Guowei class," "Daihan class" established by Guangzhou University of Traditional Chinese Medicine, "Guipai apricot class" of Guangxi University of Traditional Chinese Medicine, etc., these experimental classes are not only for clinical practice, but also for off-campus study during summer and winter holidays. These experimental classes all attach importance to the classics of Chinese medicine, allowing students to study the classics in depth and understand the way of thinking of Chinese medicine and the essence of identification and treatment of Chinese medicine. Each student in the experimental class is provided with a teacher to follow and learn from, so that they are exposed to clinical practice earlier than their counterparts in other ordinary classes, and are significantly better than their counterparts in the application of Chinese medicine thinking and clinical ability. Teachers teach by example, imparting clinical experience, medical ethics, and the cultural connotations of Chinese medicine. Through this mode of teacher-training education, students can more easily combine theory with clinical practice, which enables them to pass on the essence of the culture of Chinese medicine in its original form, and students can learn directly from the teacher's experience in the areas of diagnosis, treatment, and medication techniques. This phased follow-up mode effectively connects the theoretical courses, forming a virtuous cycle of "theoretical learning-clinical verification-theoretical enhancement," and realizing the organic integration of teacher training and modern academic education.

8. Integration of Chinese medicine teacher education and modern Chinese medicine talent cultivation

Although teacher education has its unique advantages, with the development of the times, teacher education also needs to keep pace with the times, optimizing the existing model on the original basis^[17]. To promote the development of teacher training education for academic postgraduate students of traditional Chinese medicine, it is necessary to combine the essence of traditional teacher training with the modern education system, and constantly explore the teacher training mode, which is of great significance to the cultivation of high-quality, high-level Chinese medicine talent team construction, as follows.

8.1. Integrating the experience of famous Chinese medicine practitioners to deepen the teaching content

The law of success of Chinese medicine talents shows that many famous and old Chinese medicine experts can only form their personal unique academic insights after they are old and experienced, and the inheritance and research of these valuable academic insights are relatively insufficient^[18]. To strengthen the inheritance of the academic experience of famous and old Chinese medicine experts, to build a number of national famous and old Chinese medicine experts inheritance studio, to apply the rich experience and technology of the elderly Chinese medicine experts to clinical practice, to explore and collate the canonical books into the improvement of clinical efficacy of the concepts and methods, and to increase the strength of the living inheritance^[19]. Teacher inheritance of famous doctors is the best way for Chinese medicine practitioners to become successful^[20], through the establishment of various forms of mentorship, follow-the-teacher system, academic succession and inheritance programs, academic thought inheritance studio of famous doctors and teachers, and other carriers and channels, constantly digging out and refining the core essence of Chinese medicine teacher inheritance education, and integrating it with the concepts of modern institutional education and the system of cultivation of talents in Chinese medicine^[21]. During this period, students should make good notes of their supervisors, follow up medical cases or practical records, and carefully understand and comprehend them, as well as write their own experience to comprehensively and systematically inherit their supervisors' academic thinking, clinical experience, or technical expertise^[22]. Explore on their own the unique identification methods that can accurately reflect the thinking characteristics of famous and old Chinese medicine experts, and master their clinical thinking patterns and ability to identify diseases, so as to lay a foundation for improving the level of clinical identification and enhancing the efficiency of Chinese medicine inheritance^[23]. We will gradually learn to understand the academic thinking and clinical skills of famous and old Chinese medicine practitioners, and pass on the torch of Chinese medicine.

8.2. Teacher practice and classical validation

The foundation of becoming an excellent Chinese medicine clinician is to familiarize oneself with the classics of Chinese medicine: “the classics are the foundation, and the teacher’s inheritance is the key.” The classics of Chinese medicine contain the profound relationship between heaven, earth, and human beings, and store the essence of Chinese medicine that has been used for thousands of years to treat the sick and save people’s lives, which is the source of living water for the academic development of Chinese medicine^[24]. Currently, Chinese medicine colleges and universities offer a large number of Western medicine courses, and the curriculum of classical Chinese medicine courses has been reduced. Some of them are even elective courses, which leads to medical students ignoring the importance of the four classics of Chinese medicine, having a shallow foundation in the classics of Chinese medicine, favoring the study of Western medicine, and habitually adopting the

way of thinking of Western medicine ^[25]. If postgraduate students of Chinese medicine want to consolidate the foundation of Chinese medicine, they must be well versed in the classical writings of Chinese medicine, strengthen the study of the classical theories of Chinese medicine in recitation of the classics, innovate on the basis of understanding and interpreting the classics of Chinese medicine, and explore the true meaning of the classics ^[26]. In the process of classical course learning and outpatient learning with teachers, one should also learn to learn by example, and internalize the knowledge of classical Chinese medicine into one's own clinical diagnosis and treatment ideas ^[27], and really learn the classics and use them well. Learning to use, integrate, and strive to achieve the purpose of learning Chinese medicine classics in the classroom, and use Chinese medicine classics to solve clinical problems outside the classroom. Institutions can carry out regular lectures on TCM classics to cultivate postgraduate students' thinking in TCM and facilitate their clinical guidance ^[28]. The classics of TCM are the living soul of TCM, and teacher education ensures the purity and vitality of TCM academics through the trinity model of "classics + clinical + teacher transmission." Only by taking root in the classics can we cultivate real Chinese medicine talents who have both a profound theoretical foundation and the ability to solve clinical problems flexibly.

8.3. Dual tutor system joint training

Clinical supervisors often have heavy clinical work, but the training of students' scientific research ability is relatively insufficient, and they are unable to take into account the training of postgraduate students' scientific research and clinical ability. In the "dual tutor system," clinical tutors are mainly responsible for the cultivation of students' clinical practice ability, guiding students to analyze typical cases, helping students to find clinical problems, guiding clinical practice, and strengthening the cultivation of students' clinical thinking ^[22]; academic tutors are mainly responsible for the academic guidance on scientific research ideas and research methods, and are mainly responsible for graduate students' research topic selection, research method training, research process supervision and management. Guangzhou University of Traditional Chinese Medicine (GZUTM) has further innovated the integration of resources by means of a university-enterprise dual-mentor postgraduate training system to cultivate talents in the related fields in an all-round way ^[29]. The implementation of the scientific research-clinical dual-tutor training model, which effectively integrates the resources of medical schools and affiliated hospitals, has fully leveraged their respective advantages and significantly improved the quality of medical postgraduate training. This model is worthy of further exploration and practice ^[30].

9. Conclusion

Through the trinity model of "Clinical-Classical-Teacher-Transmission," TCM teacher-training education not only makes up for the practical shortcomings of institutional education, but also is a key path to meet the challenges of modern medical education. Teacher-training education is of great significance to the clinical and scientific research of academic postgraduates in Chinese medicine. In the clinical aspect, through the teacher training, students can follow the teacher into the clinical practice, observe the diagnosis and treatment ideas and methods from a close distance, learn from his rich clinical experience, transform the theoretical knowledge into the actual clinical skills faster, cultivate the clinical thinking and the ability to solve problems, improve the clinical skills, and learn to make accurate judgement and effective treatment of complex conditions. In the clinical follow-up, we help them to explore valuable scientific research problems and grasp the direction of scientific research, and at the same time, we pass on the academic spirit, create a good scientific research

atmosphere, cultivate their innovative thinking and scientific research quality, and promote the output of scientific research results. Through the construction of a systematic follow-up system, it injects sustainable power for the development of Chinese medicine inheritance and innovation.

Disclosure statement

The authors declare no conflict of interest.

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Digital Art: The New Role of the Metaverse in Art Education

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Abstract: The rise of digital art education not only brings new technical means for art education, but also injects new vitality into it. Metaverse, as a cutting-edge digital platform, can provide a more immersive and interactive learning experience for art education, break the limitations of traditional education, and promote the comprehensive innovation of art education. This study aims to explore the potential of meta-universe in art education by analyzing the specific impact of meta-universe on art education and revealing its unique advantages in enhancing the quality of teaching, enriching learning resources, and stimulating students' creativity. It is hoped that through this study, multiple possibilities of meta-universe application in art education will be discovered, providing theoretical and practical support for future development.

Keywords: Digital art; Metaverse; Art education

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1. Basic concepts and technical foundations of the metaverse

1.1. Definition of meta-universe

Metaverse is a highly integrated and futuristic concept that combines the virtual and real worlds to form a new digital space. In this space, users can not only participate in various interactive activities through virtual images, but also experience a sense of immersion beyond reality. Metaverse is not just a simple extension of virtual reality, but a multi-level, multi-dimensional digital ecosystem that covers socialization, entertainment, learning, creation, and more. At its core, it provides a seamless connection between the virtual and real worlds, enabling users to explore, communicate, and create freely within it ^[1].

1.2. Technological base

Virtual reality technology: Virtual reality technology makes users feel as if they are in another world through a highly realistic 3D environment simulation. In art education, VR technology can be used to create virtual galleries, virtual art studios, etc., so that students can visit famous paintings, observe the details of sculptures, and even copy masterpieces in a virtual environment. This not only greatly enriches learning resources but also provides students with a more realistic, creative experience.

Augmented reality: Augmented reality technology is the superimposition of virtual information on the real world so that the two can be seamlessly combined. In art education, AR can be used to enhance the interactivity of classroom instruction. For example, students can see the creation process of a painting through AR glasses or place virtual artworks in reality to observe and analyze them from different perspectives. This technological tool not only improves the fun of learning but also enhances students' understanding and memory ^[2].

Blockchain technology: Blockchain technology plays an important role in the meta-universe with its decentralized and untamperable features. Especially in art education, blockchain can ensure the copyright and owner's rights of artworks. Students can learn how to utilize blockchain technology to protect their works and trade and share them securely in the metaverse. In addition, blockchain can record students' creative process and results, providing reliable data support for evaluation and feedback ^[3].

Artificial intelligence technology: Artificial intelligence (AI) technology provides intelligent assistants and virtual tutor capabilities in the meta-universe. Through machine learning and natural language processing, AI can provide students with personalized learning suggestions and real-time feedback. During the creative process, AI can assist students in design, color matching, and composition analysis, and even generate preliminary artworks for students' reference. This intelligent support not only improves the efficiency of learning but also stimulates students' creativity ^[4].

1.3. Properties of the metaverse

Immersive experience: Immersive experiences are one of the most distinctive features of the metaverse. Through highly realistic virtual environments, students can be completely immersed in a work of art or the process of creating art. For example, when visiting a virtual gallery, students can feel as if they are in the atmosphere of the Louvre; in a virtual art studio, students can try out various materials and tools with their hands and engage in real creative practices. This immersive experience not only enhances the fun and interactivity of learning but also helps students better understand and master art knowledge.

Interactivity and collaboration: Metaverse offers a high degree of interactivity and collaboration, allowing students and teachers to communicate and collaborate in real time in a virtual space. Students can participate in art discussions, share creative inspirations, and even communicate with art enthusiasts and professionals around the world through their virtual identities. In team projects, students can collaborate to complete artworks and work together to solve problems in creation. This interaction and collaboration not only promote deeper learning but also develop students' teamwork and social skills ^[5].

Creative combination of the virtual and the real: Metaverse is unique in its ability to combine the virtual and real worlds, offering new possibilities for artistic creation. Students can not only create in a virtual environment, but also bring virtual works into the real world through technological means. For example, using 3D printing technology, students can turn virtual sculptures into physical works of art; through AR technology, students can display their virtual paintings in real space. This creative way of combining virtual and real not only broadens the boundaries of artistic creation but also provides students with richer means of expression.

2. Examples of the application of meta-universe in art education

2.1. Virtual art exhibition

Virtual art exhibitions are one of the most intuitive and extensive applications of metaverse in art education. Through virtual galleries, metaverse can display world masterpieces and works of emerging artists, providing students with a platform for art learning without geographical restrictions. For example, the virtual art gallery

project of Shanghai Jiaotong University presents classic masterpieces such as Leonardo da Vinci's Mona Lisa and Van Gogh's Starry Night in the form of high-precision three-dimensional models, so that students can gain an in-depth understanding of each painting's creative background, technical characteristics, and historical value through virtual tours. In addition, the virtual gallery also provides multi-level interactive experiences, such as the artwork anatomy function, which allows students to analyze the hierarchical structure of a painting layer by layer and understand the use and meaning of each stroke, greatly enriching the content and form of learning ^[6].

2.2. Virtual art studio

Virtual art studios simulate real creative environments and provide students with unlimited creative possibilities. The virtual art studio program at Peking University is a typical example. In the program, students can enter a highly realistic virtual studio and create art using a variety of virtual art tools and materials. For example, they can use virtual brushes, paints, sculpting tools, etc., to learn about different art forms and techniques. The virtual studio also supports multi-person collaboration, allowing students to work with their teacher or other classmates to complete artworks together in the same virtual space. This environment not only helps students master practical skills but also stimulates their creative thinking and teamwork ^[7].

2.3. Online art courses

Online art courses in the meta-universe utilize virtual classrooms and laboratories to achieve the perfect combination of real-time instruction and practice. Stanford University's online art program is an example of a successful application. The virtual classroom allows instructors to conduct real-time lectures and students to participate in class discussions through avatars, ask questions, and receive timely feedback. The virtual laboratory provides rich practical resources, for example, students can conduct virtual color matching experiments to learn the mixing effect of different pigments, or create sculptures in the virtual space to experience the texture and weight of different materials. This kind of online course not only breaks through the spatial limitation of traditional teaching, but also enhances students' learning motivation and practical ability ^[8].

2.4. Interdisciplinary cooperation and innovation

The use of meta-universes in art education also promotes interdisciplinary cooperation and innovation. The combination of art and technology is a distinctive feature of this field. For example, the "Digital Art Creation and Programming" course launched by the Royal College of Art in the United Kingdom combines art creation and programming technology, allowing students to create interactive artworks in virtual space. Students control the dynamic effects of virtual artworks through programming, which increases the interactivity and viewability of the artworks. In addition, the crossover between art and other disciplines such as sociology and psychology has brought new perspectives to art education. In the "Art and Social Science and Technology" course of the Massachusetts Institute of Technology (MIT) in the United States, students explore the role of art in social change through the meta-universe platform and analyze the impact of artworks on people's psychology, and this kind of cross-disciplinary learning not only broadens students' knowledge, but also cultivates their comprehensive quality and innovation ability ^[9].

3. Impacts of the meta-universe on art education

3.1. Broadening the boundaries of art education

The emergence of the meta-universe has greatly broadened the boundaries of art education. First of all, it breaks

the geographical limitations and realizes globalized art education. Traditional art education is often limited by physical space and resources, making it difficult for many students to experience world-class art resources in person. In the metaverse, however, students can easily visit major museums, galleries, and art studios around the world, interact with global art masters and scholars, and learn and explore the mysteries of art together. For example, the Metropolitan Museum of Art in New York has opened up its rich art collection to global users through the metaverse platform, and students can gain a deeper understanding of the historical and cultural background of each artwork through virtual tours, which greatly enriches their learning resources. Secondly, metaverse provides more learning resources and opportunities. Various art scenes can be simulated in the virtual environment, such as ancient art workshops, modern art studios, etc. Students can practice and explore in these environments. In addition, digital artifacts and virtual course resources in the metaverse greatly enrich the learning content. Through these resources, students can come into contact with artworks of different styles and genres and broaden their artistic horizons^[10].

3.2. Enhancing the learning experience and effectiveness

Metaverse significantly improves the learning experience and effectiveness of art education by building immersive learning environments. Immersive technologies provide students with an immersive learning experience that enables them to understand the details of artworks and the creative process in greater depth. For example, the University of London's Virtual Art Studio program enables students to experience real painting and sculpture creation processes in a virtual environment through high-precision 3D simulations. This kind of immersive learning not only enhances students' hands-on ability but also improves their aesthetic and creative level. In addition, metaverse supports personalized learning paths and content. Artificial intelligence technology can provide personalized learning suggestions and resource pushes based on each student's learning needs and interests. By analyzing students' learning data, the system can dynamically adjust course content and difficulty so that each student can progress on the path that best suits them. For example, Tsinghua University's art education platform uses AI technology to customize personalized learning plans for students, helping them find their own unique style in art creation.

3.3. Promoting diversity in artistic creation

The meta-universe has not only changed the way of art education, but also promoted diversity in art creation. In traditional art creation, many artists are limited by materials, techniques, and environments that make it difficult to realize certain creative ideas. In the metaverse, these limitations are greatly broken. Virtual reality technology provides artists with new creative tools and platforms, enabling them to experiment with a variety of unprecedented art forms. For example, artists can paint in three-dimensional space through virtual brushes to create dynamic, multi-dimensional artworks. In addition, interdisciplinary collaboration in the metaverse brings new inspiration for art creation. Artists can collaborate with scholars in other fields, such as science and technology experts, sociologists, psychologists, etc., to explore new artistic expressions and creative themes. Such collaboration not only broadens the field of art but also provides students with more creative ideas and methods. For example, the Art and Technology Interdisciplinary Program at the University of California, Berkeley, encourages students to combine AR technology to create interactive artworks, which are not only ornamental but also socially significant and psychologically impactful.

3.4. Development of new media art

The meta-universe provides a broad space for the development of new media art. New media art refers to artworks created by means of modern technology, such as digital technology, network technology, and computer software. In the meta-universe, the creation and display of new media art become more convenient

and diversified. Artists can create multimedia artworks, such as virtual reality movies and interactive art installations, through virtual reality technology, which can be appreciated and interacted with by a global audience in the virtual space. For example, James Turrell, an internationally renowned new media artist, utilized the meta-universe platform to create a series of virtual reality light and shadow works. These works not only give people a strong visual impact but also provide a brand new feeling in terms of interactive experience. By participating in the creation and presentation of these works, students can learn the latest technology and presentation methods of new media art, which will lay a solid foundation for their future career development.

4. Future prospects for art education in the meta-universe

4.1. Development and refinement of technology

The future development of meta-universe art education cannot be separated from the continuous progress and improvement of technology. First of all, more advanced virtual reality equipment will be the focus of technological development. Although the current VR equipment has been able to provide a more realistic immersion experience, there is still much room for improvement. Future VR equipment will be lighter, more comfortable, higher resolution, and can realize more delicate tactile feedback, so that users in the virtual environment will feel as if they were there. This will greatly enhance the learning experience of students, so that they can more naturally use a variety of artistic tools in the virtual studio. Secondly, smarter educational aids will also be one of the directions of technological development. Artificial intelligence technology will be further applied to the field of education to provide students with personalized learning advice and real-time creative guidance. For example, an intelligent tutoring system can analyze a student's work, point out potential problems, and provide improvement solutions; a virtual tutor can provide targeted advice and support when a student encounters a creative bottleneck. These smart tools will make art education more efficient and scientific, helping students make significant progress in a short period of time.

4.2. Innovations in education models

The future of meta-universe art education will also bring innovations in education models. Hybrid teaching models that integrate online and offline will become more and more common. Online, students can receive real-time lectures through virtual classrooms and utilize virtual laboratories for creative practice; offline, students can participate in physical exhibitions and workshops, applying the skills learned online to real-world operations. This hybrid model not only breaks the fixed pattern of traditional education, but also enables students to flexibly switch between different scenarios and acquire more comprehensive knowledge and skills. Project-based learning and creation are another important innovation in the education model. Under this model, students will learn and practice around specific art projects, and they are required to participate personally in every step of the process, from planning, creation, to presentation. For example, Peking University's Art and Technology Project course requires students to design an interactive art installation in a virtual environment and present their results in an offline physical exhibition. This project-based teaching mode not only cultivates students' practical skills but also enhances their sense of innovation and teamwork.

4.3. Ethical and legal issues

As metaverse art education continues to develop, ethical and legal issues are emerging. First, data privacy and security are important issues that need to be addressed. Students' learning data and creative works on the metaverse platform involve personal privacy, and the platform needs to develop strict data protection measures

to ensure that this information is not misused. For example, the European Union’s General Data Protection Regulation (GDPR) provides strict regulations on data privacy protection, and meta-universe platforms should follow similar standards to protect users’ data security. Secondly, the protection of the property rights of artworks is also an issue that cannot be ignored. In the meta-universe, the copying and dissemination of digital artworks become very easy, and how to protect the intellectual property rights of creators and prevent piracy and infringement will be a problem that needs to be focused on and solved in the future. Blockchain technology can play an important role in this regard by generating unique digital certificates for each artwork to ensure its copyright and the owner’s rights. For example, China’s National Copyright Administration is exploring the application of blockchain technology in digital copyright protection, and will promote this technology in the Yuan Universe platform in the future to provide strong support for the protection of property rights of artworks.

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A Study on Magical Realist Writing Techniques Used in *Men of Maize*

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Abstract: Miguel Ángel Asturias' work titled *Men of Maize* stands as a significant masterpiece within the realm of Latin American magical realism literature. It unfolds and discloses the profound and abiding antagonism that exists between Indian culture and modern capitalism by means of a prose narrative that is rendered in a poeticized fashion, replete with rich mythological symbols as well as complex social conflicts that are intricately interwoven. This paper undertakes an analysis across four distinct aspects, namely the backdrop or setting against which the work was created, the very definition along with the characteristic features that are emblematic of magical realism, the context or background within which it came into being and subsequently developed, and the specific and tangible manifestations of the magical realist writing techniques as they are exemplified in *Men of Maize*. The study that has been conducted reveals that *Men of Maize* manages to demonstrate the historical fissure or divide and the cultural antagonism that pervades Latin American society through the employment of techniques such as the clash of cultures, a non-traditional narrative structure that breaks away from the norm, and the symbolism associated with deities. Moreover, it simultaneously engages in a profound and incisive reflection upon the marginalization of traditional culture during the course of the modernization process. The creative output of Asturias is not solely a critique leveled at the social reality of Latin America; rather, it also represents an exploration of the common issues and challenges that are faced by mankind at large, thereby laying down an important and substantial foundation for the further development of magical realism literature.

Keywords: Magical realism; *Men of Maize*; Techniques of magical realist writing

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1. Introduction

Men of Maize is a classic work by Guatemalan author Miguel Ángel Asturias, first published in 1949. It is based on the unique social, historical, and cultural background of Latin America, and utilizes a magical realist approach to explore the conflict and integration between Indian culture and modern capitalism. At the beginning of his work, Asturias was deeply influenced by the class conflicts in Guatemalan society and the oppression of the Indians, and he incorporated myths, religions, and folklore into his work, thus constructing a world of art

that intertwines reality and fantasy. The purpose of this paper is to analyze the situation and the socio-cultural significance of the magical realism in *Men of Maize*, and to reveal the work's profound reflection on the history, culture, and social reality of Latin America. By exploring the techniques of culture clash, unconventional narrative structure, and deity symbolism, the paper further illustrates the important position of *Men of Maize* in the development of magical realism literature and the profound impact it has had on global literature.

2. Background of Men of Maize and its influence

Miguel Ángel Asturias is one of the most important founding fathers of Guatemalan literature, and his work *Hombres de Maíz* marks the early exploration and maturation of the magical realism genre in Latin American literature. Closely related to the history, social structure, and cultural complexity of the region, the novel is a detailed portrayal of the conflicts and contradictions of traditional Indians in the midst of the process of modernization. *Men of Maize* is not only Asturias' masterpiece, but is also recognized as a particularly important turning point in the development of magical realism.

In the course of his work, Asturias used poetic prose narrative techniques, rich and varied mythological symbols, and complex social conflicts, through which he clearly articulated his own profound critical attitude and in-depth reflection on Latin American society and culture ^[1]. The background material for Asturias' work is the class conflict in Guatemalan society and the deep antagonism between Indians and Latinos (Ladinos). During his childhood, Asturias experienced the poverty of Guatemala's indigenous society and witnessed the gradual decline of Indian culture, as well as the brutal reality of Indian subjugation and oppression. This special experience became an extremely important source for him to create the work *Men of Maize*. Through artistic processing, Asturias deeply explores the actual situation of inequality in the society after the end of colonization, especially focusing on the process of marginalization of the Indians in the emerging modern capitalist system.

3. Overview of magical realism

3.1. Definition and characteristics of magic realism

Magic realism focuses on integrating the real world with supernatural or strange elements to create a double feeling of "reality-illusion" that is hard to distinguish. Compared with traditional realism literature, magic realism is not only limited to the portrayal of external social reality, but it also uses myth, fantasy, and supernatural elements to realize a combination of the conventional presentation of reality, in order to show the deep symbolic meaning of the real world.

It began in Europe in the 1920s, flourished in Latin America between 1930 and 1950, and spread rapidly around the world between 1960 and 1970. The term first appeared in the context of German painting and art in December 1925, when the German art critic Franz Roh published the book *Magic Realism and Post-Expressionism: Some Problems of New Painting in Contemporary Europe*, in which the term Magic Realism was first given. Originally used to describe the "new trend" of paintings that took as their subject the economic downturn and the misery of the population in Germany after World War I, Franz Roh's article was translated into Spanish and published in 1927 in the internationally influential Spanish periodical *Revista Occidental*; In 1948, the Venezuelan writer Uslar Petri introduced the term to Latin American literature and began to use it systematically in Spanish-language American literary criticism. Magical realism is famous for its unique "magic" elements, which skillfully integrates the magical and unpredictable things into the portrayal of real life, breaking through the limitations set by traditional thinking, and presenting one after another marvelous

things that are beyond common sense and hard to say clearly. Magical realism has a unique narrative method that is not bound by time and space, skillfully blending reality and fantasy together, making readers feel as if they are in a world that is both familiar and unfamiliar at the same time. In this world, mystical, fantastical, and supernatural elements are intertwined with each other, bringing readers a reading experience they have never had before. Magical realism is not only a depiction of reality, but also a profound reflection on reality. By revealing the absurdity and irrationality of the real world, it prompts readers to think deeply about life, society, and human nature. The global spread of magic realism has also promoted the exchange and integration of different cultures. It enables writers and artists from all over the world to explore some common problems of human beings together, and enhances mutual understanding and respect among different cultures. Such cross-cultural exchanges have not only enriched the connotation of magic realism but also made it an indispensable part of global literature and art. It closely focuses on social reality and reveals the problems and contradictions in the real world by distorting and transcending reality. This kind of concern and reflection on reality makes magic realism have profound social significance and practical value.

In *Men of Maize*, Asturias skillfully integrates myths, religions, and folklore with the narrative content, thus creating a unique atmosphere in which it is difficult to distinguish the real from the imaginary, and one seems to be in the midst of a lost dream. The novel does not simply treat the magical elements as decorative details in the passages, but rather intertwines them closely with the real world, building an artistic world that encompasses both the real and the surreal. Such a fusion not only changes the traditional narrative structure but also creates a close and deep connection between the depiction of reality and the cultural perception of the Indians.

3.2. Background and development of magical realism

3.2.1. Background

Magic realism belongs to a unique literary genre that integrates daily life with fantasy and supernatural elements, thus presenting a literary style between reality and fantasy. The formation of magical realism is based on a complex and varied historical, cultural, and social background ^[2].

The historical and social background of Latin America:

The rise of magical realism is closely related to the long history of colonization, social upheaval, and cultural mixing in Latin America. In Latin America, Spanish and Portuguese colonialism had a far-reaching impact, not only introducing European culture and religion but also colliding with the traditions, myths, and cultures of the indigenous peoples, and resulting in a fusion of cultures ^[3]. This clash of cultures is a social reality unique to Latin America, where many writers have used magic realism to express their personal views on social injustice, political violence, and social conflicts.

Influence of modernism:

At the beginning of the 20th century, modernist literature focused on breaking away from traditional narrative forms and exploring the relationship between the individual's inner world and social reality. The genre of magical realism was in fact influenced by modernist literature, specifically in its experiments with time, space, narrative structure, and language. Writers tend to distort reality in order to reveal the complexity of the human condition and the social context.

Influence of native folk culture and religion:

The people of Latin America are largely influenced by folklore, religious beliefs, and myths, and these traditions play an important role in the formation of magical realism. Writers integrated those myths and religious rituals with their daily lives, thus creating a realist literary style with mystical colors.

3.2.2. Development

1940s: Early exploration and influence:

Magical realism is a distinctive literary style that first emerged in Latin American literature in the 1940s. Early writers like Julio Cortázar of Argentina and García Márquez of Colombia set out to combine elements of the everyday with the fantastic. Cortázar's short story *The Jumping Place* and Marquez's *The Devil and the Lady* are two examples of the genre's beginnings.

1960s: "The explosion of Latin American literature":

In the 1960s, magical realism flourished in Latin America and was called the "explosion of Latin American literature." It was during this period that many writers began the process of writing a large number of novels characterized by magical realism, which gained widespread attention around the world. One of the most well-known masterpieces is Garcia Marquez's *One Hundred Years of Solitude*, published in 1967, which has become a representative work of magical realism and has had a profound impact on the global literary world. *One Hundred Years of Solitude* intertwines Latin American history, culture, politics, and fantasy to bring out a series of themes such as family destiny, political violence, and social change.

The 1970s and 1980s saw the maturation and globalization of magical realism:

After the success of *One Hundred Years of Solitude*, magical realism became globalized, and the influence of the writers began to spread around the world. Writers continued to explore how to combine the everyday with the fantastic, seeking to show human emotions and social conflicts in a more subtle and diverse way. Writers such as Mario Vargas Llosa and Carlos Fuentes have also begun to devote themselves to the creation of magical realism, which, to a large extent, has pushed this literary genre towards maturity.

From the 1990s to the present, the influence and re-creation of magic realism:

Since the 1990s, although magic realism no longer occupies the position of the mainstream literary genre, its influence is still quite far-reaching. Many modern writers have incorporated many elements of magical realism into their works, resulting in a unique style known as "post-magical realism." Take the Chilean author Isabel Allende's *The House of Ghosts*, which utilizes the narrative techniques of magic realism with additional feminist elements. In addition to this, magic realism has also been used in cinema, for example, in the movie *Pan's Labyrinth* directed by Guillermo del Toro.

4. Embodiment of magical realist writing techniques in the work

4.1. The lost paradise: Clash of cultures and integration

One of the key central themes of *The Cornhuskers* is the clash of cultures and the state of integration ^[4]. Through the detailed description of the relationship between Indians and Latinos, the novel brings out the deep and obvious opposition between two different civilizations and two different ways of life. On the one hand, the Indians have always adhered to the traditional civilization based on the land and nature, which is an important symbol of survival and culture, and has been deeply integrated into the life of the Indians as well as their belief system. On the other hand, Latinos (especially Ladinos) represent a modern civilization based on commodification and capitalism, which is characterized by exploitation, coercion, and consumption. In Asturias' work, the threat of modernization to the traditional way of life is well represented by the encroachment of the Ladino on the lives of the Indians. In this novel, Asturias depicts this cultural conflict through the use of magical realism and contrasts the deep-rooted values of the Indians with those of the capitalist society through the presentation of Indian myths, religions, and cultures. Through magical events and characters, such as the mythologizing of Gaspar Irón, he expresses his views on the destruction of indigenous traditions by

modernization and his defense of traditional culture.

4.2. Dislocated time and space: Non-traditional narrative structure

Men of Maize employs an unconventional narrative structure in which time and space are dislocated, and the traditional linear narrative pattern is broken. There are many storylines in the novel, which are intertwined and intermixed in time and space, and Asturias creates a chaotic and surreal atmosphere with this narrative technique, which makes the boundary between reality and fantasy ambiguous. This dislocation of time and space strengthens the mystery of the novel on the one hand, and adds to its fantasy color on the other, while reinforcing the metaphorical effect on the split situation of the real society as well as the rupture of history. By adopting such a narrative style, Asturias not only breaks the traditional structure of literature in terms of form but also reveals the profound cultural and historical conflicts in Latin American societies in terms of content. In the work *Men of Maize*, Asturias lets readers truly experience a non-linear and irrational flow of time, and the intertwining of history and reality more realistically reveals the chaos and uncertainty of Latin American society ^[5].

4.3. Ubiquitous deities: Intertwining virtual and reality

The gods and supernatural forces in *Men of Maize* belong to a very prominent category of magical realism. The myths and religious beliefs in this novel do not exist only as background elements, but are closely related to the destiny of the characters and the change of society. Asturias creates a world in which the virtual and the real are intertwined through the use of mythological deities, witchcraft, and traditional Indian beliefs. In this novel, the gods are not only supernatural beings, but their actions and events have an impact on the real world and directly shape the destinies of the characters ^[6]. In Asturias' creative activity, the gods symbolize a force against the oppression of modernity. Through the use of myth and religion, Asturias illustrates how the Indians, in the face of modernization and colonialism, relied on their beliefs and traditions to maintain their identity and vitality.

4.4. The doomed ending: Hints and symbols

The ending of *Men of Maize* is full of allusions and symbols that bring out the unresolved situation of cultural and historical conflict ^[7]. The novel does not dispose of the conflict with a simple ending, but uses symbolism to reveal the deep-seated historical cycles and cultural regeneration of Latin American societies. At the end of the novel, the conflict between traditional culture and modernization is not really resolved, but is instead embodied by means of magic and myth. This ending is on the one hand a cry in defense of traditional culture, and on the other hand a deep reflection on the injustice of modern society and the many problems left over by history ^[8].

4.5. Visual illusion

In *Men of Maize*, Asturias uses the technique of optical illusion to interweave reality with fantasy. With this technique, many of the scenes in the novel have an ambiguous and irrational atmosphere, which allows the reader to experience the feeling of being in a "virtual reality." This technique intensifies the magic of the work and reinforces the symbolic effect of the work in presenting the rifts and cultural oppositions that exist in the history of Latin American societies.

4.5.1. Multiple symbols

Asturias uses the element of corn as an extremely important symbol in his novels. It is important to know that corn is a symbol of life and culture in the Mayan culture, and it also embodies the close relationship between human beings and nature. He blended the corn with people, events, and the natural environment, thus creating

a symbolism that is multilayered. Corn exists as a kind of food, and it carries not only the survival needs of the Maya people, but also represents the spiritual and cultural roots of the Maya people. In the novel, corn is often closely associated with traditional Mayan religious ceremonies and seasonal changes, which further strengthens the symbolism of corn.

Asturias also uses the depiction of nature, such as mountains, forests, and rivers, to intertwine them with mythological deities and creatures, so that the line between reality and myth becomes blurred. This fusion of nature and myth on the one hand allows the reader to experience a sense of beauty with unreal colors, and on the other hand makes the world in which the story is set full of mysterious and surreal atmosphere.

4.5.2. Perspective shift

Asturias uses multi-perspective narrative means, in which each perspective presents the unique personal experience and cognitive status of different characters, and these perspectives often have their own prejudices and limitations. Such a multi-perspective narrative can prompt readers to search for the truth in different perspectives, and the different narrative styles of each character will make readers create some kind of cognitive illusion. In such a process, Asturias intentionally blurs the so-called “real” face of the story, breaking the boundaries of the traditional single narrative perspective, and turning each character’s perspective into a kind of “partial truth.” This makes each character’s perspective a “local truth,” and ultimately makes the whole story full of complexity and a certain sense of depth.

Asturias also skillfully utilizes the technique of unreliable narrators. Some of the narrators are influenced by their personal experiences and emotions in their descriptions. It is this unreliability that makes the reader more skeptical about the authenticity of the story, allowing them to feel the distortions and illusions of the story as their perceptions continue to shift.

4.5.3. Time dislocation

The narrative time in *Men of Maize* is not linear, it mainly uses flashbacks and pre-narrative techniques to make the story jump back and forth between different points in time^[9]. By virtue of such a non-linear narrative, Asturias successfully breaks the traditional chronological structure, which in turn allows the reader to feel the illusion of time and the sense of chaos brought about by the chaotic time jumps. In this way, the structure of the story becomes more and more complex, and also increases the challenge to the traditional narrative time, so that when the reader goes to understand the story line, it will inevitably produce a lot of difficulties and confusion, as if the time and space itself has been twisted and distorted in general.

Asturias employs a cyclical narrative technique in his book, in which parts of the plot and themes are repeated in different chapters, forming a cyclical structure. This structure allows readers to experience the repetition of time and the sense of endlessness, as if everything is constantly cycling back and forth, and this illusion makes the story look more and more mysterious, and at the same time, it also carries a kind of feeling that is difficult for people to escape.

4.5.4. Mental illusion

Asturias intertwines dreams with reality, which makes the reader blur the line between the two. In *Men of Maize*, dreams and illusions are depicted throughout the work. There are many episodes and experiences of the characters that make it difficult for the reader to distinguish between what is real and what is unreal. With this technique, Asturias enhances the mystery of the story and sets the characters and plots of the story in a surreal

atmosphere, presenting a state of realism and ambiguity at the same time.

The language and descriptions in the novels often continue to give psychological hints to the readers. For example, Asturias' detailed depiction of Mayan life evokes in the reader a sense of longing for traditional culture and a sense of respect. In particular, his poetic expression of natural scenery and Mayan traditions allows the reader to experience an emotional belonging, and then to reach a cultural level of identity, and ultimately creates a specific psychological illusion that makes people believe that this traditional way of life is actually the idealized one.

4.5.5. Language play

In *Men of Maize* ^[10], Asturias skillfully uses language that is paradoxical and contradictory in nature, so that the reader is prompted to think about the story as he or she understands it. For example, the description of the conflict between modern civilization and traditional Mayan culture reveals the contradictions and paradoxes between the two. With his paradoxical language, Asturias allows the reader to deeply feel the eroding effects of modernization and the painful struggle of traditional culture, which in fact reflects the profound conflict in Latin American societies.

Asturias' skillful use of repetition and variation creates an illusion of familiarity and unfamiliarity for the reader. There are words or phrases that are repeated in different contexts, and each repetition has subtle variations. Such repetitions and variations are particularly prominent in the description of Mayan rituals and traditional practices, enabling the reader to truly feel the disruption of time and space in the successive echoes.

4.5.6. Cross-sensory depiction

In his novels, Asturias uses the fusion of the senses to create a new perceptual experience, prompting the reader to create a cross-sensory illusion. For example, he uses the expression "warm sound" to portray the auditory experience, or "sweet smile" to depict the visual experience. Such a fusion of senses makes the reader's perception no longer limited to a single sense, but rather, through the intertwining of multiple senses, the reader is able to truly feel the richness and layering of every detail in the story.

Disclosure statement

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Research on Visual Teaching of Analytic Geometry Based on GeoGebra Software

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Abstract: This paper delves into the visual teaching of analytic geometry facilitated by GeoGebra software. Through a meticulous analysis of the current landscape of analytic geometry instruction and the distinct advantages of GeoGebra software, it expounds upon the imperative and feasibility of its application within the realm of analytic geometry teaching. Furthermore, it presents a detailed account of the teaching practice process grounded in this software, encompassing teaching design and the demonstration of teaching cases, and conducts an in-depth investigation and analysis of the teaching outcomes. The research findings indicate that the GeoGebra software can effectively elevate the level of visualization in analytic geometry teaching, thereby augmenting students' learning enthusiasm and comprehension capabilities. It thus offers novel perspectives and methodologies for the pedagogical reform of analytic geometry.

Keywords: GeoGebra software; Analytic geometry; Visual teaching

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1. Introduction

Analytic geometry is intricately intertwined with mathematics across nearly all domains, and its instructional significance cannot be overstated under any circumstances. The study of geometry plays a pivotal role in fostering students' capabilities in problem-solving, conjecture-making, deductive reasoning, intuition, visualization, logical argumentation, and proof construction^[1,2]. Nevertheless, the abstract concepts and convoluted figures inherent in analytic geometry frequently present formidable challenges to students' learning endeavors. Traditional teaching approaches, which predominantly rely on static chalkboard notations and formula derivations, struggle to satiate students' need to grasp the dynamic transformations of geometric figures. In the context of analytic geometry, students are often confronted with the visualization dilemmas associated with abstract figures such as ellipses and hyperbolas. Empirical research has demonstrated that students aided by dynamic software are more predisposed to establish the "integration of number and shape" mindset, with a concomitant increase of 23% in the accuracy rate of problem-solving^[3].

Visual teaching is an instructional approach that translates abstract knowledge, data, and concepts into tangible forms through visual modalities such as images, charts, animations, and videos. This facilitates students' intuitive comprehension and mastery of the subject matter. Dynamic visualization, in particular, encompasses a suite of visual presentations and interactive animations designed to elucidate abstract concepts^[4]. A substantial body of research has meticulously explored the nexus between the integration of dynamic visualization in pedagogy and students' advancement and performance in mathematics learning^[5,6].

GeoGebra, developed by Markus Hohenwarter at the University of Salzburg in 2001, seamlessly integrates geometry, algebra, and calculus. It is adept at managing the inter-relationships among geometric elements such as points, lines, polygons, and circles, along with facilitating the use of basic tools and commands^[7,8]. Extensive scholarship has attested to its suitability for mathematics instruction^[9,10]. For students across all educational levels, GeoGebra synergistically combines the strengths of dynamic geometry software and computer algebra systems^[11,12]. Abundant empirical investigations have unequivocally demonstrated that GeoGebra can augment the efficacy of mathematics learning^[5,9,13,14]. In a study^[15], GeoGebra was implemented in the geometry instruction for students majoring in mathematics education and in-service educators. Employing purposive sampling techniques, two public institutions of higher learning were chosen as the research foci. The findings indicated statistically significant enhancements in students' academic achievements and enthusiasm for geometry learning and teaching. Furthermore, the GeoGebra-based teaching methodology rendered the curriculum more hands-on and accessible.

2. Analysis of the current situation of analytic geometry teaching

2.1. Limitations of traditional teaching methods

In traditional analytic geometry teaching, instructors predominantly impart knowledge through blackboard writing and oral explanations. For simple geometric figures such as lines and circles, teachers can draw and explain them on the blackboard. However, when it comes to complex quadratic surfaces like ellipsoids and hyperboloids, it is extremely challenging to accurately and clearly depict their shapes on the blackboard. As a result, students find it arduous to intuitively comprehend the forms and properties of these figures. Moreover, in traditional teaching, the teacher's instruction is often one-way, with students passively receiving knowledge. They lack opportunities for active participation and hands-on practice, which is detrimental to the cultivation of their innovative thinking and practical abilities.

2.2. Difficulties in students' learning

Analytic geometry courses are characterized by a high degree of abstraction and logical rigor. Students are tasked with conjuring geometric figures in their minds and forging connections between these figures and algebraic equations. Nevertheless, the spatial visualization and abstract reasoning faculties of the majority of students remain underdeveloped. As such, they encounter substantial hurdles in grappling with abstract concepts like vector operations and the parametric equations of spatial curves.

Moreover, throughout the learning trajectory, students are bereft of intuitive graphical expositions and dynamic transformation sequences. This dearth impedes their ability to fathom the profound interrelationships between geometric figures and algebraic equations, thereby engendering tepid enthusiasm for learning and subpar academic outcomes.