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EXPLORING THE ASSOCIATION BETWEEN SOCIAL MEDIA USE AND PROSOCIAL BEHAVIOR IN POLICE CADETS

HuSheng Xu[1*], JiaWen Xu[2]
[1]*Department of Police Management, Jiangsu Police Institute, Nanjing 210031, Jiangsu, China.*
[2]*Jiangsu Key Lab of Remote Measurement and Control, School of Instrument Science and Engineering, Southeast University, Nanjing 210096, Jiangsu, China.*
[*]*Corresponding Author: HuSheng Xu*

Abstract: China's social media development is attracting scholars to shift their research topics from international to domestic. Researchers bring negative comments on platforms such as "Xuexi Qiangguo". Our study focuses on general situation of young college students using of social media, as well as aim to understand perceived stress, job values and knowledge sharing. We selected senior cadets of police college, who are young undergraduate students, and also have an important mission of political capacity building. Based on the previous questionnaire and statistic methods, our research found that students using "Xuexi Qiangguo" social media app more correlated to less stress, higher commitment to police work, and more knowledge sharing in prosocial, self-efficacy and real-world behaviors. Our research shows high correlation between using of the "Xuexi Qiangguo" and better students. It also provides frameworks for exploring the app's education function to young students.
Keywords: Xuexi Qiangguo; Perceived stress; Job value; Knowledge sharing

1 INTRODUCTION

In recent years, social media platforms like Facebook and Google have played significant socio-economic and cultural roles globally[1]. As tools for promoting public safety, current international research on police use of social media primarily explores what police tend to do on these platforms [2, 3]. Other studies focus on the impact of social media use on policing work [4], such as improving police-public communication [5]. Previous research has mainly concentrated on the most popular platforms in Western countries. An International Association of Chiefs of Police (IACP) survey indicated that Facebook, Twitter, and YouTube are the three most widely used social media platforms by police agencies [6]. Recently, scholars have begun to recognize the importance of Chinese platforms. In fact, the global ecosystem of social media platforms is largely dominated by American and Chinese companies [7, 8]. China's high-tech giants like Alibaba, ByteDance, Baidu, and Tencent are key players in the social media platform industry [9, 10], with Alibaba and Baidu providing technology and data for the construction of China's social system [11]. In China, the number of college students using social network applications like WeChat, QQ, and Weibo is rapidly increasing [12]. The development of China's social media platforms, such as Weibo, Douyin (TikTok in China), and Bilibili, provides online users with powerful infrastructure for open communication, collaboration, and mobilization [13, 14].
Douyin, the video-sharing platform owned by ByteDance, has become one of the most downloaded applications globally. These developments have prompted scholars to study Chinese social media platforms like Douyin, iQiyi, WeChat, and Kuaishou [15-18]. Despite the increasing diversity of internet platforms and the growing prominence of interactive platforms like Bilibili, Kuaishou, Douyin, Xiaohongshu, and "Xuexi Qiangguo", most research focuses on a few platforms like Weibo and WeChat. Meanwhile, Western scholars have begun to project their own views by accusing the government manipulates public opinion through the "Xuexi Qiangguo" platform, falsely claiming that platform users are punished for low scores in study groups [19]. Domestic research on the "Xuexi Qiangguo" platform, however, is more concentrated in the field of ideological education [20-23]. In the book "Patriotic Education in a Global Age", Randall Curren and Charles Dorn offer profound reflections on civic virtue, promoting and furthering academic research on patriotic education [24]. The rapid adoption of social media technologies by youth and college students, among whom high levels of social media use are particularly common, can help us develop new methods for patriotic education.
Police cadets are future law enforcement officers. As young college students, they are active users of social media platforms. Social media platforms influence police cadets in various ways. Understanding their social media use, particularly the extent of their use of the "Xuexi Qiangguo" platform, is crucial for deepening our understanding of future police officers and clarifying Western arrogance and prejudice.
Considering the social characteristics of police cadets, our study, based on understanding the general situation of social media use among them, focuses on three aspects: Perceived Stress, Job Value, and Knowledge Sharing behavior, by analyzing the stress, their professional values, and specific prosocial performances in knowledge sharing.

1.1 Social Media Use and Stress

Cohen's (1983) research showed that when life's stress exceeds a person's adaptive capacity, it increases the risk of illness, and the perception of stress can lead to negative emotional states. Psychological stress is considered a broad physiological and behavioral process that can lead to poor health habits, increased disease risk, and accelerated illness [25]. Students experiencing psychological stress use social media to cope and find sources of support, as well as to procrastinate or pass the time. Students view social media as a way to release academic pressure [26]. Mao found among 200 students that WeChat was used for relaxation and stress relief [27]. Hou [12], while studying WeChat addiction, also found that participating students used WeChat to cope with loneliness and stress.

Compared to other professions, the nature of police work is a significant stressor; always preparing for the worst is a deeply ingrained motto in the police mindset [28]. Senior police cadets who have undergone six months of practical training in police stations have already had direct experience with the stress of police work. However, for cadets who need to balance social media use with efforts to prepare for the civil service exam, does the use of the "Xuexi Qiangguo" platform, impose an additional burden on police cadets?

1.2 Social Media Use and Job Values

Various professions (social workers, teachers, journalists, etc.) have explored job values [29]. Students in educational programs oriented towards clients and students (e.g., social workers and teachers) tend to value altruistic values more than those in programs not oriented towards clients or students (e.g., journalists). Currently, few is known about the job values of police cadets. Although the job values of police cadets have not been explicitly studied, some international research has examined their motivations for choosing police work. These studies indicate that many factors are important in choosing a police career, such as the opportunity to help others and the willingness to enforce the law [30, 31]. Another factor that seems to attract people to become police cadets is that policing is perceived as an exciting and adventurous profession. Furthermore, practical reasons are also important, such as job security and stable salaries, leading individuals to choose police work [32]. Research on motivations for becoming a police officer suggests these motivations can be described as dimensions of job values, namely intrinsic values, extrinsic values, and altruistic values.

Extrinsic values relate to the instrumental aspects of work, providing external rewards or satisfaction. They include values such as pursuing financial success and high income, job security, promotion opportunities, status, and power. Hartung et al., based on Super's career development lifecycle theory, considered work values like management, workplace, security, prestige, and income as belonging to extrinsic values [33]. Furthermore, Leuty and Hansen revealed that these work values, along with achievement, are moderately positively correlated with extrinsic rewards. Lifestyle is also considered an extrinsic value [34]. Intrinsic values are reflected in an internal psychological satisfaction derived from the work itself. They include general values such as autonomy, interesting and meaningful tasks, challenge, variety, emotional intimacy, community contribution, altruism, and personal growth. Creativity, challenge, variety, achievement, lifestyle, aesthetics, and autonomy (or independence) are categorized as intrinsic values. Work values like creativity, challenge, variety, and achievement are moderately positively correlated with intrinsic rewards [35].

Job values are crucial for any industry as they are closely linked to organizational stability and competitiveness. Given the importance of job values for cadets, from an educator's perspective, it is necessary to study the relationship between police cadets' job values themselves and their use of social media platforms.

1.3 Social Media Use and Knowledge Sharing

According to Duggan and Brenner [36], 83% of young people aged 18-29 disseminate information through social media platforms. For police cadets facing the upcoming civil service exam, the behavioral manifestation that best reflects noble job values is arguably the sharing of exam knowledge. Knowledge dissemination among police cadets helps foster a knowledge-sharing culture within the university and is a primary way for police colleges to help cultivate knowledge-based officers, who can make valuable contributions to knowledge flow in future public security work. Although the use of different social media for informal learning is becoming increasingly common among students, among the different knowledge exchanges occurring within and between university stakeholder groups, knowledge sharing among students is an aspect rarely focused on in the existing literature on knowledge sharing in the university context. Although some papers use survey methods to explore knowledge-sharing behaviors among college students [37], systematic exploration of the various ways students share knowledge remains scarce.

Social media makes it easier for users to make new friends, enhance online harmony, expand social networks, and mobilize collective action more effectively. Social media platforms can help facilitate offline social interactions among college students. Among the different knowledge exchanges occurring within and between university stakeholder groups, knowledge sharing among students in the university context is an aspect rarely focused on in the existing literature [38]. By re-examining the extent of use of the "Xuexi Qiangguo" platform, we will explore the behavioral characteristics of knowledge sharing among police cadets during preparation for the most important career exam, the civil service exam, by designed questionnaires.

2 RESEARCH DESIGN

2.1 Participants

The police cadets in the study were all senior public security majors who had completed internships at local police stations. They were all aged 21 or 22, originally from two student cohorts totaling 100 people (85 male, 15 female). Six male students transferred due to academic performance and did not participate in the survey. The remaining 94 individuals, including 15 females, all participated. When responding to the questionnaire, the researchers explained the purpose of the survey to all cadets, and participation was stated to be entirely voluntary. The questionnaire did not record names or ID numbers. At the time of completing the questionnaire, all cadets were preparing for the civil service examination. Ultimately, all cadets joined the police force.

2.2 Questionnaires

2.2.1 Survey on social media platform use intensity

Based on a pilot survey, researchers selected 18 social media platforms that police cadets might frequently use (Figure 1). Participating cadets were asked to rate their use frequency and time spent on each platform on a 1-5 scale (1=almost never use, 2=occasionally use, 3=moderate use, 4=use quite frequently, 5=use very frequently, almost daily).

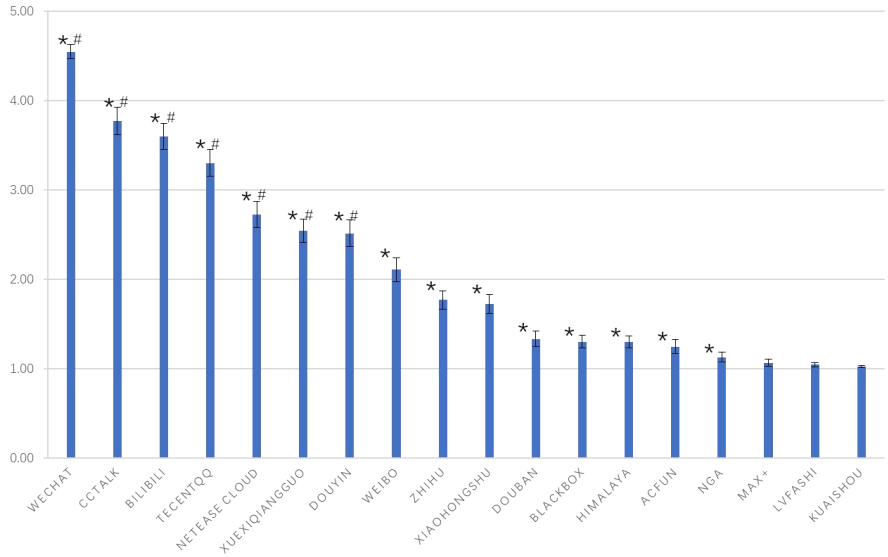

Figure 1 Ranking of Social Media Use Intensity for 18 Platforms
*Indicates One-sample t-test significantly greater than constant 1(p<0.05)
# Indicates One-sample t-test significantly greater than constant 2(p<0.05)

2.2.2 Perceived stress scale

Referencing Cohen [25], the study employed the 14-item Perceived Stress Scale (PSS-14) to assess the degree to which individuals felt stressed in their lives. After reversing the scores for 7 of the items, a higher total score indicated greater perceived stress.

2.2.3 Measurement of police job values

Based on Sundström, police cadets were asked to rate 12 work value statements related to the police work on a 1-5 scale [39], according to their personal perception of the police profession and the degree to which each statement matched their personal view (1=completely disagree, 5=completely agree). The 12 items formed three measurement parts: Extrinsic Values, Intrinsic Values, and Altruistic Values.

2.2.4 Knowledge sharing behavior

A 16-item questionnaire was designed based on Tseng [40]. The items targeted specific thoughts and behaviors during the civil service exam preparation period, divided into three parts: Prosocial Commitment, Self-efficacy in Knowledge Sharing, and Knowledge Sharing Behavior Performance. Participating police cadets also rated each item on a 1-5 scale regarding the degree to which it corresponded to the current reality, from completely disagree to completely agree.

2.3 Data Analysis

2.3.1 Descriptive statistics and grouping for social media platform use

SPSS 26 was used for descriptive statistics on the ratings of the 18 social media platforms. One-sample t-tests were conducted to compare the ratings against the reference values of 1 (almost never use) and 2 (occasionally use) to check for significant differences. Pearson's correlation analysis was performed on the ratings of platforms whose scores were significantly greater than 2.

Based on the ratings, cadets were simply grouped: those rating the "Xuexi Qiangguo" platform 1 or 2 formed the Low Use Group (Low Group), and those rating it 3, 4, or 5 formed the High Use Group (High Group).

2.3.2 Processing of measurement scales

Based on the questionnaire structure, scores were calculated for each cadet's Perceived Stress, Extrinsic/Intrinsic/Altruistic Job Values, and Prosocial Commitment/Self-efficacy/Behavioral Performance in Knowledge Sharing.

2.3.3 Inter-group and paired comparisons

Independent Samples t-tests were conducted using SPSS 26 to compare the measurement results between the two groups (High vs. Low "Xuexi Qiangguo" use) for significant differences. Paired Samples t-tests were conducted between different measurement items.

3 RESULTS

3.1 General Situation of Social Media Use

From the descriptive statistics (Figure 1), we can see that the Chinese social and multi-purpose application WeChat is indeed an indispensable part of police cadets' daily lives, having become one of the most popular social media platforms globally. As college students facing the civil service exam, the learning-oriented social media platform CCTALK became the second most popular software after WeChat. Domestically, CCTALK is a well-known channel for online and video course learning and exchange, containing very little recreational internet content. Another well-known social media platform with similar use intensity is Bilibili, which serves both as a platform for video course learning and for recreational content, functionally somewhat similar to YouTube in Western countries. However, both CCTALK and Bilibili still show significant differences compared to WeChat use intensity: t(WeChat-CCTALK)=4.497, $p<0.01$; t(WeChat-Bilibili)=5.499, $p<0.01$.

Correlation analysis of social media platform use intensity (Table 1) showed that the learning-oriented CCTALK correlated with Bilibili and "Xuexi Qiangguo". Bilibili use also correlated with Douyin, which is primarily used for entertainment. Western scholars treated the "Xuexi Qiangguo" platform as an extension of propaganda for manipulating public opinion and social control [41-43]. The questionnaire results reveal that students are exposed to and use a wide variety of social media platform types. In the subjective reports of police cadets, both "Xuexi Qiangguo" and Douyin are used as common social software, serving both learning and entertainment purposes, fundamentally different from the Western academic discourse [44].

Table 1 Correlation Analysis of Usage Intensity for 7 Social Media Platforms

Coefficient r	CCTALK	Bilibili	Tencent QQ	NetEase Cloud	Douyin	Xuexi Qiangguo
WeChat	-0.010	-0.081	0.027	0.129	0.000	0.047
CCTALK		-0.229*	-0.027	0.060	0.026	0.258*
Bilibili			0.271**	0.039	-0.424**	0.039
Tencent QQ				0.071	-0.185	0.176
NetEase Cloud					-0.035	0.090
Douyin						-0.029

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

3.2 "Xuexi Qiangguo" Platform Use and Perceived Stress

Based on the descriptive results of social media platform use intensity (Table 2), the "Xuexi Qiangguo" platform, used for learning and resource acquisition, and the Douyin platform, used for entertainment, form a suitable pair for comparison. Therefore, similar to the "Xuexi Qiangguo" grouping, cadets were simply grouped based on their ratings: those rating 1 or 2 formed the Low Use Group, and those rating 3, 4, or 5 formed the High Use Group. For the "Xuexi Qiangguo" platform, the High Group had 46 people, and the Low Group had 48 people. For Douyin platform use, the High Group had 42 people, and the Low Group had 52 people (Table 3). Among the police cadets preparing for the civil service exam, there was no widespread addiction or excessive use of Douyin despite its short-form, fragmented, and highly stimulating characteristics [45].

Table 2 Top 7 Social Media Platforms by Usage Intensity

Intensity	WeChat	CCTALK	Bilibili	Tencent QQ	NetEase Cloud	Xuexi Qiangguo	Douyin
Mean	4.54	3.77	3.60	3.30	2.72	2.54	2.51
Std.D	0.767	1.491	1.432	1.465	1.410	1.269	1.464

Table 3 Inter-group Comparisons (Xuexi Qiangguo vs. Douyin)

Inter-group Comparison		Xuexi Qiangguo Platform					Douyin Platform				
		N	Mean	Std.D	t-value	Sig *p* (2-tailed)	N	Mean	Std.D	t-value	Sig *p* (2-tailed)
Perceived Stress	High G.	46	2.79	0.611	-3.077	0.003**	42	2.96	0.599	-0.477	0.634
	Low G.	48	3.2	0.675			52	3.03	0.732		
Extrinsic Values	High G.	46	4.13	0.611	2.132	0.036*	42	3.96	0.576	-0.452	0.652
	Low G.	48	3.86	0.615			52	4.02	0.665		
Altruism Values	High G.	46	4.49	0.628	2.143	0.035*	42	4.37	0.766	0.446	0.657

Inter-group Comparison		Xuexi Qiangguo Platform					Douyin Platform				
		N	Mean	Std.D	t-value	Sig *p* (2-tailed)	N	Mean	Std.D	t-value	Sig *p* (2-tailed)
Intrinsic Values	Low G.	48	4.19	0.743	2.036	0.045*	52	4.31	0.653	0.267	0.79
	High G.	46	2.13	0.452			42	2.04	0.547		
Prosocial Commitment	Low G.	48	1.92	0.54	2.404	0.018*	52	2.01	0.478	0.813	0.418
	High G.	46	4	0.681			42	3.88	0.705		
Self-efficacy	Low G.	48	3.62	0.821	3.004	0.003**	52	3.75	0.829	0.591	0.556
	High G.	46	3.57	0.693			42	3.38	0.599		
Behavioral Performance	Low G.	48	3.09	0.844	2.254	0.027*	52	3.28	0.945	1.089	0.279
	High G.	46	3.38	0.891			42	3.28	0.911		
	Low G.	48	2.97	0.879			52	3.08	0.897		

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

Judging by the motives for use, facing the pressure of employment exams, police cadets did not become addicted to Douyin. Users of the "Xuexi Qiangguo" platform were primarily motivated by the need to acquire information resources for exam preparation. Comparing the Perceived Stress between the High and Low groups, we found that the "Xuexi Qiangguo" High Group had significantly lower perceived stress: t(High-Low)=-3.077, $p<0.01$, whereas for Douyin, there was no significant difference in perceived stress between the High and Low groups (Table 3). High use intensity of the "Xuexi Qiangguo" platform did not lead to higher perceived stress or become a task burden for students during exam preparation. Therefore, the negative views of Western scholars regarding the "Xuexi Qiangguo" platform are groundless.

4 DISCUSSION AND CONCLUSION

4.1 Police Work Requires Higher Job Values

From a human resource management perspective, an important distinction in work is between extrinsic and intrinsic values [46]. Extrinsic work values focus on the outcomes of work, for which people receive tangible rewards related to the economic functions of the job, such as salary, prestige, or job security. In contrast, intrinsic values focus on work outcomes associated with psychological rewards, such as recognition, growth opportunities, and flourishing [47]. Therefore, extrinsic or intrinsic work values can lead to a variety of motivations and require different management tools and practices. Without distinguishing between High and Low groups, for the overall student perspective, the extrinsic value of the police profession far exceeds its intrinsic value: t(Extrinsic-Intrinsic) =29.256, $p<0.01$. This aligns with reality, as police work is a stable civil service job and offers competitive local income for undergraduates.

Previous research on job values indicates differences in the importance placed on different work values by students in different professional programs. Comparisons of work values across different professions (teachers, preschool teachers, social workers, journalists) show that professions with clinical/client contact value the altruistic aspects of work more than those without such contact. As expected, since the police profession, like teaching and social work, is a people-oriented profession, it should be similar. For the overall students, Altruism as the highest: t(Altruistic-Intrinsic) =32.233, $p<0.01$; t(Altruistic-Extrinsic) =4.92, $p<0.01$.

The "Xuexi Qiangguo" High Group scored significantly higher than the Low Group on all three job value aspects: Extrinsic Values, Intrinsic Values, and Altruism (Table 3), whereas the Douyin High and Low groups showed no significant differences. Although higher "Xuexi Qiangguo" platform use associated with higher job values does not indicate causality, it can serve as an indicative characteristic. It can be inferred that in our daily work of selecting excellent police officers, subjective questions about the intensity of "Xuexi Qiangguo" platform use could be incorporated into the assessment process as one of the auxiliary reference selection criteria.

4.2 Knowledge Sharing Behavior

Self-fulfillment and enhancing personal understanding and learning ability are motivations for knowledge sharing. Police cadets sharing knowledge with friends and classmates satisfies higher-level human needs and is also a concrete behavioral manifestation of police professional values. It can be stated without hesitation that the most important task for police cadets during their four-year undergraduate education is the civil service exam. Therefore, evaluating knowledge-sharing behavior during exam preparation can better assess cadets' professional values. The "Xuexi Qiangguo" High Group had significantly higher scores than the Low Group in Prosocial Commitment (t=2.404, $p<0.05$), Self-efficacy (t=3.004, $p<0.01$), and Knowledge Sharing Behavior Performance (t=2.254, $p<0.05$) within knowledge sharing behavior (Table 3), while the Douyin High and Low groups showed no significant differences. In terms of specific behavioral performance, the "Xuexi Qiangguo" High Group was more willing to share civil service exam knowledge and exhibited more knowledge-sharing behaviors.

From the perspective of Prosocial Commitment, an individual's willingness to voluntarily help, share, donate, and cooperate within a group reflects the relational dimension of social capital [48] and can promote their prosocial behavior, benefit others or achieving common goals. Prosocial fundamentally stems from altruistic motivations—moral

concern and emotional functions to express compassion for others [49]. Besides altruistic motives, egoistic motives are also key factors influencing individual prosocial behavior [50]. Individuals may attempt to maximize their reputation and welfare by helping others and expecting future reciprocal returns. Blau's social exchange perspective suggests that individuals contribute effort to help others in close relationships to enhance their own image [51], increase social approval, anticipate future help, and maintain ongoing relationships. Furthermore, egoistic motivations benefit skill improvement, mood, sense of distinction and importance, and contribute to further teamwork and cooperation.

From the perspective of Self-efficacy, it influences individuals' expectations about potential outcomes and subsequent courses of action. It is considered an important self-regulatory mechanism in the interaction between individuals and their environment. Beliefs in one's ability to complete specific tasks further influence the strategies used to achieve goals, the amount of effort expended, perseverance in the face of obstacles and adversity, the ability to recover from setbacks, and the feasibility of achieving goals. Social interaction contributes to collective beliefs about knowledge sharing; classmates pool their knowledge, skills, and resources, provide mutual support, form alliances, cooperate to solve problems, and improve the quality of member learning [52].

The emergence of prosocial is not only a matter of altruistic or egoistic motives in response to others' needs but also a response to members' identification with and commitment to their group. The "Xuexi Qiangguo" High Group may, through positive interpersonal relationships, help individuals enhance their sense of self-worth and self-esteem, achieved through instrumental help or emotional support in the sharing environment, which further influences individual achievement motivation. Similarly, when team members share common interests and goals with peers, they are more confident in their ability to contribute useful knowledge to others rather than feeling anxious in social situations. By establishing and maintaining relationships among members, the vicarious experiences generated by social models help them realize the possibility of behavioral achievement.

We selected senior police cadets preparing for the civil service exam as our research subjects, hoping to demonstrate, under the conditions of diversified social media platforms and the stigmatization of the "Xuexi Qiangguo" platform, whether members with dual identities as ordinary college students and police cadets face more stress, possess higher professional values, and exhibit better knowledge-sharing behaviors during exam preparation. Undoubtedly, our research results are positive and optimistic.

5 FUTURE STUDY

Results based on subjective reports and simple grouped statistical comparisons are still insufficient to describe clear causal relationships. Therefore, further, more objective and quantitative evaluation of social media platform usage is needed to analyze deeper usage patterns and underlying reasons. On the other hand, while work values are relatively stable for most adults as measured by self-report scales [53, 54], they may change over time due to professional experience, career maturity, and work outcomes. Although having gained sufficient understanding of police work through six months of internship, police cadets might adopt different coping strategies in stressful situations after starting work, potentially leading to changes in their work values. Therefore, maintaining these high levels of altruistic values during the educational process is an important issue facing police educators.

The current study provides a framework for discussion and analysis exploring the education of young college students and makes the future research needs and practical value of platforms similar to "Xuexi Qiangguo". Although there is increasing research on social media platform use, there is still much to be further explored regarding job values and specific behaviors.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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CONSTRUCTION AND APPLICATION OF A THREE-DIMENSIONAL EVALUATION SYSTEM FOR EMPLOYMENT QUALITY OF HIGHER VOCATIONAL GRADUATES: PROFESSIONAL FIT - STAKEHOLDER SATISFACTION - CAREER DEVELOPMENT CAPABILITY

YuanYu Li
Guangdong Vocational institute of Public Administration, Guangzhou 510550, Guangdong, China.

Abstract: Addressing the common challenges in current higher vocational education employment quality assessments—such as "reliance on single metrics, fragmented data, and delayed feedback"—this paper draws from practical experiences in vocational education to develop a three-dimensional evaluation framework: "Program-Industry Fit - Stakeholder Satisfaction - Career Development Capability". Grounded in the principles of being "perceptible, communicable, and actionable," the framework employs concrete methods like matching programs with industry codes, conducting graduate satisfaction surveys, and following up with career development tracking. These approaches transform abstract quality indicators into tangible, actionable markers represented by symbols—"circle, smiley face, and arrow"—and utilize a "red-yellow-green" traffic-light grading system alongside a structured "six-step closed-loop" implementation process. This innovative approach effectively tackles the longstanding issues of traditional evaluations being "difficult to understand and hard to apply". Ultimately, the study aims to equip higher vocational institutions with a unified employment quality assessment framework, fostering a positive synergy between evaluation practices and talent-development reforms, while providing replicable and scalable best practices to enhance and optimize vocational education.
Keywords: Higher vocational graduates; Employment quality; A three-dimensional evaluation system; Professional suitability; Career development capabilities

1 INTRODUCTION

Employment quality is the core indicator of the quality of talent cultivation in vocational education, as well as a key metric for assessing the overall strength of higher vocational colleges. In recent years, China's higher vocational education has entered a new stage of development characterized by "improving quality, enhancing excellence, adding value, and empowering," with the national government clearly emphasizing the shift in employment evaluation from being "scale-oriented" to "quality-oriented". The "Notice from the Ministry of Education on Doing a Good Job in Employment and Entrepreneurship for 2024 Graduates of National General Higher Education Institutions" underscores the need to "establish a sound employment quality evaluation system, placing particular emphasis on assessing graduates' job satisfaction, employer recognition, and their potential for career growth"[1]. Meanwhile, the "14th Five-Year Plan for Vocational Skills Training" further calls for "building a vocational education evaluation mechanism centered on employment quality, ensuring that vocational institutions precisely align with market demands"[2]. At the provincial level, annual reports on the quality of higher vocational education issued by local education departments explicitly require each institution to establish a "school-specific employment quality evaluation system". This system must not only comply with national policy guidelines but also reflect regional industrial characteristics and the distinct institutional realities of each institution, ultimately yielding quantifiable and comparable evaluation frameworks[3].

However, current vocational education employment quality assessments still face significant, common challenges.In practice, most vocational colleges have maintained high graduate employment rates. Yet, when examining core questions more closely—such as whether programs match job requirements, whether graduates are satisfied with their positions, and whether their career paths offer long-term sustainability—the existing evaluation systems often lack unified standards and scientifically rigorous assessment methods. Some institutions still rely solely on the "employment rate" as their primary metric, neglecting the multifaceted nature of employment quality. Meanwhile, a few colleges that have attempted to develop multi-dimensional assessment frameworks have encountered issues like overly abstract indicator designs, difficulties in collecting reliable data, and misalignment with their own institutional realities[4]. This evaluation approach—focusing heavily on quantitative metrics while downplaying qualitative aspects, emphasizing outcomes over processes—fails to accurately capture graduates' employment experiences or their potential for career growth. As a result, it falls short of providing the precise data needed to guide reforms in talent development and help vocational colleges strategically adjust their program offerings. Ultimately, this disconnect leaves employment evaluations disconnected from real-world educational practices, creating a gap between theory and reality.

Based on this, the present article draws from practical experiences in higher vocational education employment

initiatives, focusing on three core dimensions—"professional alignment, stakeholder satisfaction, and career development capability"—which are both tangible in daily practice and supported by quantifiable data. These dimensions form the foundation of a "three-dimensional evaluation system" designed to assess the employment quality of higher vocational graduates. The study aims to move beyond the limitations of traditional, single-dimensional employment rate assessments, clearly defining key indicators and actionable strategies for each dimension. Ultimately, it seeks to establish an employment-quality evaluation framework that is "operational for institutions, credible to higher authorities, and replicable across similar programs". The article first examines the policy context and current challenges surrounding employment quality assessment in higher vocational education, then delves into the rationale behind the three-dimensional system, outlining its core indicators and practical implementation methods. Finally, it summarizes the system's practical value and identifies potential avenues for optimization, offering valuable insights to guide reform efforts in employment quality assessment and enhance talent development at higher vocational institutions.

2 CURRENT SITUATION ANALYSIS

Currently, the field of higher vocational education employment quality assessment exhibits an overall characteristic of "stable scale control coexisting with imbalanced quality," and these trends and challenges are widespread across the industry.

First, From the perspective of employment evaluation, the tendency to focus solely on "rates" has yet to be fundamentally reversed. Although the country has clearly signaled a shift in employment evaluation toward a quality-oriented approach, most vocational colleges still prioritize the employment placement rate as their primary assessment metric. These key indicators carry disproportionately high weight in the evaluation framework, while critical quality dimensions such as professional alignment and career development potential are often treated merely as supplementary references[5]. This focus has inadvertently directed employment initiatives toward "meeting quantitative targets," with some institutions even encouraging graduates to "take a job first before considering long-term career plans"—leading them to accept positions that may not match their academic backgrounds or provide little room for long-term career growth. As a result, the discrepancy between high employment rates and subpar employment quality has become particularly pronounced.

Second, In terms of professional suitability, the situation exhibits characteristics of "overall improvement but localized imbalances". As industry-education integration continues to deepen, the alignment between talent development in higher vocational colleges and market demands has steadily improved. Meanwhile, most traditionally strong programs—benefiting from established institutional foundations and robust industry-university collaboration networks—have maintained a high level of professional adaptability. However, emerging programs generally exhibit relatively lower adaptability, primarily because there is a "time lag" between their curriculum design and the specific skill requirements of industry roles. In some cases, practical training initiatives fail to keep pace with regional industrial upgrading trends, resulting in graduates who, while equipped with foundational competencies, still struggle to directly meet the core demands of job positions[6]. This disparity in adaptability across different programs underscores the current evaluation system's lack of a detailed assessment mechanism that specifically measures "adaptation quality".

Third,The overall satisfaction level exhibits a pattern of "highly positive overall, but uneven across individual dimensions". According to industry research, vocational college graduates generally report high overall job satisfaction. Key indicators such as "salary," "work environment," and "recognition from employers" score particularly well, while "career development opportunities" fall far behind—which stands out as the primary area for improving satisfaction[7]. In-depth interviews reveal that graduates' dissatisfaction with "career growth potential" primarily stems from two key issues: First, promotion pathways are often limited in entry-level positions, and many companies lack clear career development frameworks. Second, opportunities for enhancing professional skills remain insufficient—many graduates report that they haven't received structured training after joining their workplaces, leaving them feeling disconnected from the "sustainable development" expectations they had during their studies[8].

Fourth,The evaluation of career development capabilities suffers from the issues of "fragmented data and a lack of a comprehensive system".From a practical standpoint, the career competitiveness of higher vocational college graduates has been steadily improving. However, key data reflecting their professional development capabilities have long remained fragmented: promotion records often rely on counselors' manual tracking systems, while salary growth information is pieced together from sporadic feedback provided by employers—lacking a unified mechanism for collection, organization, and dissemination[9]. Moreover, the current evaluation framework fails to incorporate career development as a core dimension for systematic assessment, making it difficult for institutions to comprehensively monitor the long-term employment quality of their graduates and hindering their ability to deliver timely feedback for curriculum and talent-development reforms.

Fifth is Data management and horizontal comparison face a dual dilemma. At the data management level, employment-related information is scattered across multiple platforms, including provincial employment portals, student affairs systems, and individual advisors' records, creating "data silos"[10]. These datasets lack unified classification standards and integration mechanisms, with critical data such as major codes, job details, satisfaction scores, and career advancement records stored independently—making it difficult to piece them together into a comprehensive picture of employment quality. Horizontally, since measurement criteria for employment quality assessment vary across similar vocational colleges—with some focusing primarily on "job-major relevance" and others emphasizing "satisfaction"—there is a lack of unified evaluation standards. This makes it impossible for colleges to

conduct objective and meaningful cross-institutional comparisons, rendering their institutional quality evaluations largely self-referential and subjective[5].

3 FIVE MAJOR CORE ISSUES

Combining the practical logic of higher vocational education employment quality assessment, there are currently five major core issues prevalent across the industry, which hinder the scientific validity and practical guidance value of the evaluation results.

First, evaluation metrics are overly simplistic, with insufficient focus on quality. Despite the government's consistent emphasis on multi-dimensional employment quality evaluation, most higher vocational colleges still rely heavily on "rate-based metrics," with the employment rate remaining the dominant factor in performance assessments. Meanwhile, critical quality dimensions—such as job-major alignment, stakeholder satisfaction, and career development potential—are still underemphasized[11]. This singularly focused indicator design obscures the true signals of employment quality, making it difficult to fully capture graduates' employment experiences and developmental potential—and ultimately failing to provide clear guidance for reforming talent cultivation efforts.

Second, data management is fragmented, leading to a prominent issue of "data lying dormant".Graduates' employment-related data is scattered across multiple systems and storage mediums, lacking unified classification standards and an integrated mechanism, which has resulted in "data silos"[10]. Key data such as major codes, job information, satisfaction scores, and career advancement records are stored independently. Integrating this data requires manual extraction and verification across departments and systems, a process that not only consumes significant human resources but also increases the likelihood of data errors. As a result, the evaluation outcomes often fail to fully capture the true quality of employment.

Third, the feedback mechanism has become outdated, leading to a disconnect between evaluation and practice. Currently, most higher vocational colleges primarily rely on "annual summaries" as the main form of employment quality assessment. This approach involves a lengthy process—from data collection to the final output of evaluation results—while tasks such as enrollment planning, curriculum adjustments, and talent development strategy optimization must be completed within the same year[12]. As a result, delayed feedback from such evaluations hinders the timely integration of employment quality data into recruitment and instructional processes, leading to an ongoing mismatch between talent development and market demands. Thus, the practical value of these assessments is greatly reduced.

Fourth, there is fragmentation in evaluation discourse and insufficient interdepartmental collaboration. Departments such as the Employment Office, Teaching Office, and Student Affairs Office have significantly different criteria and core concerns when assessing employment quality: The Employment Office focuses on "employment rate and job availability," while the Teaching Office emphasizes "major-to-job alignment and employer satisfaction". Meanwhile, the Student Affairs Office prioritizes "graduate satisfaction and students' psychological adaptability"[13]. Each department independently develops its own evaluation metrics and collects data, lacking a unified set of standards and a cohesive discourse system. This results in "departmentalized tendencies" in evaluation outcomes, making it challenging for university leaders to obtain consistent feedback during decision-making. Consequently, this situation hampers the coordinated advancement of employment initiatives and reforms aimed at enhancing talent development.

Fifth, the evaluation methods have become overly complex and lack practical applicability. When previously, academic research on employment quality evaluation often relied on sophisticated quantitative methods such as the entropy-weight method, factor analysis, and structural equation modeling. While these approaches enhance the scholarly rigor of evaluations, they also place high demands on the professional expertise of vocational college employment management teams[11]. Typically, the employment staff at vocational institutions consists mainly of counselors and administrative personnel, who often lack specialized skills in data analysis and evaluation. As a result, existing research findings struggle to be effectively translated into practical, institution-specific strategies. Although some colleges have attempted to adopt complex evaluation models, their implementation has frequently ended up being superficial—due to the models' steep learning curves and stringent data requirements—leaving them unable to deliver meaningful insights for ongoing improvements in employment quality and institutional practices[14].

4 THREE-DIMENSIONAL EVALUATION SYSTEM DESIGN

4.1 Design Concept

This system is designed around the core objective of overcoming the challenges of "abstraction, complexity, and disconnect" in evaluating vocational education employment quality. It adheres closely to three key principles—"perceptible, communicable, and actionable"—while returning to the fundamental essence of vocational education: "student-centeredness and practicality"[15]. Building on the existing data infrastructure and operational realities of vocational colleges, the system moves away from intricate models and abstract metrics, instead adopting a progressive logic that links "professional alignment—student satisfaction—career development potential". By leveraging readily available employment-related data fields, survey responses, and alumni feedback records, it weaves together a coherent narrative of graduates' employment journeys—from"job relevance—workplace satisfaction—to long-term career growth"[16]. In doing so, the system not only aligns with national policy directives emphasizing an "employment-quality-driven approach" but also addresses the practical issues of fragmented discourse and operational hurdles inherent in institution-based evaluation frameworks. Ultimately, it achieves its design goals of ensuring "easy

data collection, clear interpretation of results, and effective decision-making,"thereby transforming employment quality assessment into a vital "bridge" that connects recruitment, curriculum development, and post-graduation placement efforts.

4.2 Dimensional Explanation

4.2.1 Professional fit: anchoring the synergy between "expertise and role"

The system focuses on the core issue of "whether talent development aligns with market demands," serving as a fundamental metric for assessing the effectiveness of industry-education integration in higher vocational education[6]. This framework employs a quantitative approach based on "code comparison and hierarchical classification": Using the major category codes from the "Catalogue of Higher Vocational Education (Associate Degree) Programs in General Institutions of Higher Education" as the benchmark, it cross-references these with job-specific industry codes from the "National Economic Industry Classification" (GB/T 4754-2017), thereby establishing a comprehensive "Major-Industry" adaptation mapping database [17]. The classification criteria are clearly defined: when a major category perfectly matches an industry role, it is categorized as "Aligned" (100% alignment); if there's a clear upstream-or-downstream relationship between the major and the industry role, it's classified as "Near" (60%-89% alignment); and when no direct link exists between the major and the industry role, it's labeled "Misaligned" (alignment below 60%). This classification method leverages the existing standardized coding system, eliminating the need to develop complex, custom metrics. Moreover, data can be directly sourced from provincial employment management platforms, ensuring both objectivity and practicality in the evaluation process[7].

4.2.2 Subject satisfaction: focusing on the alignment between "students and job roles"

The overall satisfaction level centers on graduates' employment experiences, reflecting whether "job roles align with personal expectations"—a direct manifestation of an "student-centered" approach to employment quality[7]. This system relies on the annual employment quality survey conducted by vocational colleges, using "overall satisfaction with current job" as its core indicator. A 4-point scale is employed for scoring: 1=Very Dissatisfied, 2=Somewhat Dissatisfied, 3=Moderately Satisfied, and 4=Very Satisfied. Responses rated 3 or higher (i.e., "Moderately Satisfied" or "Very Satisfied") are classified as "smiling faces," indicating that satisfaction targets have been met[18].The survey can also include additional sub-dimensions—such as "salary levels," "work environment," "company management," and "career development opportunities"—as supplementary reference indicators. However, the primary evaluation remains anchored in overall satisfaction, which not only streamlines data processing but also offers a comprehensive snapshot of graduates' employment experiences. By leveraging the colleges' existing survey infrastructure, this approach avoids redundant data collection while yielding actionable and insightful findings[8].

4.2.3 Career development strength: focusing on the growth potential of "role—future"

Career development focus is centered on whether "job positions have sustainable growth potential," serving as a key dimension for measuring the "long-term value" of employment quality[9]. This system employs an evaluation approach that combines "short-term tracking with concrete indicators": Six months after graduates join their roles, counselors conduct follow-up calls or use WeChat surveys to directly ask three critical questions: "Have you been promoted, experienced salary growth (with an increase of at least 10%), or transitioned to a higher-quality position (showing improved industry alignment and significantly higher pay)?" Meeting any one of these criteria classifies the career trajectory as "positive" (indicating favorable long-term development), while failing to meet even one criterion marks it as "stable but unchanged"[19]. This indicator design moves away from abstract concepts like "career competitiveness" or "development potential," instead translating career advancement into tangible, easily measurable outcomes—specific events that can be clearly documented. This approach not only aligns with the practical reality of vocational graduates, where job growth often manifests through changes in salary or position, but also simplifies data collection, ensuring that the evaluation results remain both authentic and highly applicable in real-world settings[14].

4.3 Levels and Scripting

To achieve the goal of "intuitive, easy-to-understand, and rapid decision-making," this system employs a "traffic light" grading mechanism, combining evaluation results from three dimensions to generate an overall assessment level according to the following specific rules:

Green light rating: "Green Checkmark + Smiling Face + Long Arrow," indicating an excellent job-major fit, high graduate satisfaction, and promising career prospects. This signifies the program delivers "high-quality" employment outcomes, with its talent development closely aligned with industry needs.

Yellow light rating: All combinations other than the green and red light options (e.g., "Matching + Smiling Face + Stable," "Close Fit + Smiling Face + Long-term," "Partial Alignment + Smiling Face + Stable," etc.), indicating "moderate" employment quality. There is room for improvement in at least one dimension—such as inadequate job-major alignment or limited career growth opportunities.

Red-light rating: "Partial + Non-smiling Face + Original," indicating low professional alignment, dissatisfaction among graduates, and limited career growth prospects. This suggests that the employment quality of this major "requires improvement," calling for a focused overhaul of the talent development program or a stronger emphasis on job-market orientation[20].

This tiered classification system eliminates complex weight calculations and score aggregations, presenting results

instead through the straightforward "Green Light (Excellent) — Yellow Light (Moderate) — Red Light (Needs Improvement)" framework. At relevant working meetings, school leaders can quickly assess the employment quality of each major—no specialized data-analysis expertise required—to make informed decisions. This approach effectively addresses the issue of "disconnect between evaluation outcomes and actionable decisions"[13].

4.4 Operation Path

This system establishes a "six-step closed-loop" operational process to ensure that evaluation efforts are efficiently implemented and their timelines remain tightly controlled. The specific steps are as follows: ①Data Pre-processing (September): Core data such as "major category codes, industry codes of employers, and job titles" for the previous year's graduates will be exported from the provincial-level university graduate employment management platform, creating a foundational database. ②Satisfaction Survey (October): An online questionnaire focusing on the key metric of "overall satisfaction" will be distributed to graduates via an online survey platform. Detailed feedback across multiple dimensions will also be collected simultaneously, ensuring a response rate of at least 90%. ③Career Development Follow-up (March of the following year): Counselors will conduct follow-up interviews with graduates who have been employed for six months, adhering to the principle of "one record per individual". Responses will clearly indicate whether the graduate has experienced "growth" or remained in their "original position," with a follow-up rate maintained at no less than 80%. ④Data Integration (April of the following year): The employment management department will input the "major alignment classification results, satisfaction 'smiley face' indicators, and career development 'growth/original' records" into a unified data table, ultimately forming a comprehensive "three-dimensional evaluation dataset". ⑤ Results Visualization (May of the following year): Based on this dataset, a "red-yellow-light overview chart of employment quality for each major" will be generated, highlighting the unique combination of dimensions and corresponding rankings for each program—clearly illustrating both strengths and areas needing improvement. ⑥Outcome Presentation (June of the following year): The red-yellow-light evaluation results will be incorporated into the annual employment quality report, which will then be submitted concurrently to university leadership, as well as relevant departments including academic affairs, admissions, and secondary colleges—providing critical insights to inform annual decision-making processes.

The entire operational process spans 9 months, markedly shortening the timeline compared with the traditional release of employment quality reports. This approach effectively addresses "delayed feedback," ensuring evaluation results promptly inform critical initiatives such as enrollment strategy adjustments and curriculum reforms[12].

4.5 Application Cases

In the practical application of the three-dimensional evaluation system, the "light-up" results for certain majors have effectively highlighted the core weaknesses affecting employment quality. For instance, some emerging fields once showed a "two yellow, one red" combination, with the primary issues revolving around insufficient program alignment and limited growth opportunities. Meanwhile, several traditionally strong programs achieved the "three green" rating, positioning them as benchmarked majors in terms of employment quality. Based on these evaluation findings, institutions can swiftly implement corrective measures—such as refining enrollment strategies, recruiting industry mentors, and revising hands-on curriculum components—creating an immediate feedback loop between "evaluation, decision-making, and improvement". This approach not only drives the collaborative advancement of program development and employment quality but also fully demonstrates the practical value of the evaluation system.

4.6 Mechanism Solidification

To prevent the evaluation process from becoming merely a formality or being abandoned halfway, institutions should integrate the three-dimensional evaluation system and the red-yellow-light grading results into their professional development management frameworks, establishing a coordinated "evaluation-incentive-restraint" mechanism [21]. It explicitly stipulates that programs receiving "green lights" for two consecutive years will be given priority in enrollment plan adjustments, receive additional funding support for teaching and research, and obtain special recommendations when applying for various high-level professional development programs. Programs flagged with a "yellow light," on the other hand, must submit detailed improvement plans and be under the joint supervision of academic affairs, career services, and other relevant departments to guide curriculum reforms and strengthen industry-university collaborations. Finally, programs receiving "red lights" for two consecutive years will be subject to enrollment plan reallocation or even temporary suspension, with a mandatory deadline to complete required rectifications[16]. By institutionalizing this evaluation framework, the "red-yellow-light" system will transition from an annual task into a regular, ongoing mechanism, ensuring continuous progress and effective implementation of employment quality assessments, ultimately fostering a positive cycle between talent cultivation and employment outcomes.

5 CONCLUSION AND DISCUSSION

This article draws on practical experiences in evaluating employment quality at higher vocational institutions. Addressing the common challenges of "single indicators, fragmented data, delayed feedback, fragmented

communication, and complex operations," it proposes a three-dimensional evaluation system centered around "professional alignment, stakeholder satisfaction, and career development capability".The system moves away from intricate quantitative models and abstract metrics, instead using three relatable, everyday terms—"harmony (professional alignment), smiley face (stakeholder satisfaction), and growth (career advancement)—to transform employment quality from "cold, impersonal data" into "vivid, human stories". This approach makes the evaluation criteria more "down-to-earth," streamlines the operational process to be "cost-effective," and presents the results in a "visually intuitive" manner, effectively overcoming the longstanding issues of traditional evaluation methods being "difficult to understand and hard to apply"[22].

From a practical perspective, the three-dimensional system provides a "common language" for campus governance: departments focused on employment, teaching, and student affairs no longer operate in isolation, instead using the "red-yellow-green light" grading system as a unified benchmark. This approach swiftly establishes a closed-loop feedback mechanism—encompassing evaluation, decision-making, and improvement—thereby enabling precise implementation of initiatives such as adjusting enrollment plans, reforming curricula, and strengthening industry-university partnerships[21]. Externally, the system leverages standardized code comparisons and concrete, measurable indicators to address the longstanding issue of inconsistent evaluation criteria among similar institutions. As a result, it offers a replicable and scalable template for conducting horizontal comparisons of employment quality across higher vocational colleges within a province, directly aligning with local education authorities' call for "collaborative development and shared use of institution-specific evaluation frameworks"[3]. At its core, this system reaffirms the "practice-oriented" nature of vocational education assessment, ensuring that employment-quality evaluations genuinely support efforts to enhance talent cultivation and meet the evolving needs of graduates—rather than merely serving academic research or compliance-driven metrics[15].

Looking ahead, this system still has room for further refinement and expansion. Temporally, the career development tracking timeframe could be extended from six months to three years, with a specific emphasis on long-term indicators such as graduates' "occupational mobility skills" and "cross-disciplinary growth potential"—offering a more holistic view of the sustainability of employment outcomes[19]. On the data front, integrating employer feedback into the evaluation framework—perhaps by introducing "employer recognition" as an additional dimension—could help create a robust, closed-loop assessment system that connects graduates, institutions, and employers[23]. Moreover, if local education authorities adopt this system as a foundation, standardizing the core metrics and evaluation criteria for vocational college employment quality across the province, it could break down the silos where institutions often evaluate themselves in isolation. This would pave the way for the establishment of a unified provincial framework for assessing vocational college employment quality, offering more precise, evidence-based support for monitoring vocational education outcomes and informing policy decisions.

When evaluating employment quality, there's no need to aim for "highbrow" academic jargon—instead, let the data speak in plain, relatable terms, and ensure that the evaluation results are actionable and grounded in reality. Only then can professional development and reform truly "take root". The three-dimensional evaluation system developed in this paper isn't the final destination for assessing vocational college graduates' employment quality; rather, it serves as the "opening statement" for a transformative shift toward a culture of quality in vocational education. This system emphasizes practicality, clarity, and effectiveness as its core principles, encouraging a shift in employment-quality assessment—from benchmarking against external standards upward, to cultivating deeper, more sustainable connections with students' real-world needs and institutional growth. Ultimately, it aims to empower both graduates' success and institutions' meaningful development[20]. Looking ahead, we must continue refining the system's indicators and operational mechanisms, providing more robust practical examples to guide the ongoing reform of employment-quality assessments in vocational education. By doing so, we can help vocational education confidently and steadily advance on its journey toward "quality enhancement and excellence improvement," paving the way for even greater achievements in the future.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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CHALLENGES IN TECHNOLOGY INNOVATION-DRIVEN ECONOMIC DEVELOPMENT: VALUE CONFLICTS AND GOVERNANCE COUNTERMEASURES IN THE APPLICATION OF ARTIFICIAL INTELLIGENCE

YuHan Xiao
Management Department, Shanghai Technician School, Shanghai 200437, China.

Abstract: In the process of global economic transformation and upgrading, Artificial Intelligence (AI), as a core field of technological innovation, has become a key force driving economic growth due to its significant role in improving production efficiency and optimizing industrial structures. However, the characteristics of AI technology, such as data dependence, algorithmic black boxes, and autonomous decision-making, while empowering economic development, have also triggered three core challenges: data application (issues of privacy protection and fairness), algorithm application (insufficient interpretability and short-term interest orientation), and labor market (structural unemployment and unfair competition). Behind these challenges, the in-depth value conflicts between efficiency and equity, innovation and sustainable development, as well as individual rights and collective interests are further highlighted. If not effectively addressed, these conflicts will restrict the sustainable application of AI technology and affect the stability of economic development.Taking AI applications as the research object, this paper systematically analyzes the specific challenges faced by AI in the process of technological innovation-driven economic development and deconstructs the logic of value conflicts behind these challenges. On this basis, targeted governance countermeasures are proposed from four dimensions: improving laws, regulations and supervision, promoting algorithm transparency, strengthening talent cultivation and employment transformation, and building a multi-stakeholder collaborative governance mechanism. The purpose is to provide theoretical support and practical reference for realizing the coordinated development of AI technology, economy and society, and promoting high-quality economic development driven by technological innovation.
Keywords: Technological innovation; Artificial Intelligence; Economic development; Value conflicts; Governance countermeasures; Employment transformation

1 INTRODUCTION

At the critical stage of global economic transformation and upgrading, technological innovation has become the core engine driving economic development. As a frontier field of technological innovation, Artificial Intelligence (AI), with its powerful data analysis, autonomous learning, and efficient decision-making capabilities, is profoundly reshaping production methods, business models, and industrial structures. From process optimization in intelligent manufacturing, intelligent risk control in the financial industry, to auxiliary disease diagnosis in the healthcare sector, the wide application of AI technology has injected strong impetus into economic growth. According to a well-known 2018 report by the McKinsey Global Institute, by 2030, AI is expected to contribute an additional approximately $13 trillion to the global economy[1].Meanwhile, PwC claims that by 2035, AI will drive a 15% growth in the global economic scale and reshape the global economic pattern [2].

However, while promoting high-speed economic development, AI technology has also triggered a series of practical application challenges due to its characteristics such as data dependence, algorithmic black boxes, and autonomous decision-making. If these challenges cannot be effectively controlled, they will not only restrict the continuous innovation and application of AI technology but also may trigger social problems, exerting a negative impact on the sustainability of economic development. Therefore, in-depth analysis of the specific challenges faced by AI applications in the process of technology innovation-driven economic development, clarifying the value conflicts involved, and proposing scientific and effective governance countermeasures have become important issues urgently to be solved by the current academic community, industry, and policymakers.

2 CORE CHALLENGES OF AI APPLICATIONS IN TECHNOLOGY INNOVATION-DRIVEN ECONOMIC DEVELOPMENT

2.1 Data Application Challenges

Data serves as the core foundation for the development and application of AI technology. The training and optimization of AI algorithms require substantial high-quality data support. In the process of technology innovation-driven economic development, enterprises often face multiple challenges in data application while pursuing higher economic efficiency

and commercial interests.

On one hand, there are difficulties in user privacy protection during data collection. When many enterprises collect user data, they fail to fully inform users of the scope, purpose, and duration of data collection, or implicitly force authorization through complex user agreements. This exposes users' personal information (such as identity information, consumption habits, and location information) to the risk of leakage. For instance, some Internet platforms construct user profiles based on users' browsing records and search history to achieve precise marketing, but they do not effectively protect the data, increasing the probability of privacy leakage.

On the other hand, there are fairness issues in data usage. Most training data for AI algorithms is derived from real society. If the data itself contains historical biases or discriminatory information and is not effectively cleaned and screened, such problems will be amplified in algorithm applications, affecting the fairness of resource allocation. For example, AI systems in the recruitment field may produce unfair screening results for job seekers from specific groups due to gender and regional biases in the training data, disrupting the normal order of the job market.

2.2 Algorithm Application Challenges

Algorithms are the core of AI technology, and their rationality, fairness, and transparency directly affect the effect of AI applications. Against the backdrop of technology innovation-driven economic development, enterprises often focus on complexity and efficiency to improve algorithm performance and competitiveness, while ignoring potential problems in applications, thus triggering algorithm application challenges. Firstly, algorithmic black boxes lead to insufficient interpretability of decisions. Due to the complexity and non-linear characteristics of AI algorithms, the decision-making process is difficult for humans to understand and trace, forming an "algorithmic black box".

In fields involving major interest decisions such as financial credit and judicial assistance, algorithmic black boxes result in a lack of transparency in decision-making results. Once errors or unfairness occur, users find it difficult to safeguard their legitimate rights and interests. For example, some banks use AI algorithms to assess borrowers' credit risks and determine loan amounts, but borrowers cannot know the specific reasons for loan rejection nor make effective appeals. Secondly, algorithm optimization is oriented towards short-term interests. Under the pressure of economic development, enterprises often take economic interests as the primary goal of AI algorithm optimization, ignoring the impact on public interests. For example, the AI recommendation algorithms of some social media platforms excessively recommend vulgar and homogeneous content to increase user activity and stay time. Although this improves platform traffic and revenue in the short term, it has a negative impact on the quality of information obtained by users and the social information environment.

2.3 Labor Market Challenges

The innovation and application of AI technology play a role in promoting economic structure upgrading and production efficiency improvement. Joseph Briggs and Devesh Kodnani, economists at Goldman Sachs Research, point out that the business process changes triggered by these technological advancements may affect 300 million full-time jobs due to AI automation[3]. At the same time, it also exerts a profound impact on the labor market, bringing about a series of employment challenges. On one hand, AI technology leads to the replacement of some traditional jobs, causing structural unemployment. With the penetration of AI technology in fields such as manufacturing and services, repetitive and low-skilled jobs (such as assembly line workers, basic customer service representatives, and traditional bank tellers) are gradually replaced by AI robots and intelligent systems, putting a large number of workers at risk of unemployment. Research by PwC shows that by 2030, AI and automation technologies will replace 20%-25% of low-skilled manufacturing jobs worldwide[2]. Although AI technology also creates new job opportunities (such as AI algorithm engineers and data analysts), these new jobs have high skill requirements and cannot absorb a large number of displaced low-skilled workers in the short term, resulting in an imbalance between supply and demand in the labor market and exacerbating the problem of structural unemployment. On the other hand, AI technology intensifies unfair competition in the job market. The research and application of AI technology require substantial capital and technology investment. Large enterprises and technology giants, relying on their capital strength and technological advantages, can take the lead in realizing the industrial application of AI technology, occupy a dominant position in market competition, and further squeeze the living space of small and medium-sized enterprises. However, small and medium-sized enterprises are an important force in absorbing employment. The shrinking of their living space will inevitably lead to a reduction in job opportunities, intensifying the unfairness of competition in the job market.

3 VALUE CONFLICTS BEHIND THE APPLICATION OF AI TECHNOLOGY

3.1 Value Conflict Between Efficiency and Fairness

In the process of technology innovation-driven economic development, the application of AI technology takes improving economic efficiency as its core goal and promotes economic growth by optimizing production processes, reducing costs, and enhancing resource allocation efficiency. However, while improving efficiency, the application of AI technology also exacerbates the imbalance of social fairness[4].

On one hand, AI technology leads to a more concentrated distribution of wealth. Due to the high investment threshold for the research and application of AI technology, large enterprises and technology giants can take the lead in mastering

and applying AI technology, obtaining more economic benefits, concentrating wealth in the hands of a few groups, and widening the gap between the rich and the poor.

On the other hand, AI technology leads to unfair opportunity distribution. As mentioned earlier, in the structural unemployment caused by AI technology, low-skilled workers find it difficult to obtain new employment opportunities due to the lack of skills adapted to the AI era, further exacerbating the inequality of opportunities in the job market. This value conflict between efficiency and fairness reflects the neglect of social fairness in the process of AI technology promoting economic development. If not properly resolved, it will affect social stability and sustainable economic development.

3.2 Value Conflict Between Innovation and Sustainable Development

Technological innovation is the core driving force for the development and application of AI technology, and also an important source driving economic development. However, in the pursuit of technological innovation, enterprises and research institutions often take technological breakthroughs and commercial success as their primary goals, ignoring considerations for social sustainable development, thus triggering a value conflict between innovation and sustainable development. For example, some research institutions are eager to carry out research projects with potential social impacts to gain an advantage in the field of AI technology, but fail to fully evaluate the impact of these projects on long-term social development; some enterprises, in order to launch new AI products and seize market share, ignore the protection of user rights and public interests during the R&D and promotion process, resulting in obvious defects in products and affecting social sustainable development. This value conflict exposes AI technology to the risk of unsustainable application while developing rapidly, restricting the long-term driving effect of technological innovation on economic development.

3.3 Value Conflict Between Individual Rights and Collective Interests

There is also an obvious value conflict between individual rights and collective interests in the application of AI. On one hand, the application of AI technology requires the collection and use of a large amount of personal data to realize algorithm training and optimization, which may infringe on individuals' legitimate rights such as the right to privacy and data control to a certain extent. On the other hand, the application of AI technology can bring significant collective interests to society, such as improving the efficiency of public services, enhancing the level of social governance, and promoting sustainable economic development. For example, in the prevention and control of public health emergencies, AI technology provides support for prevention and control work by analyzing epidemic data, ensuring public health and safety and the stable operation of society. However, this process also involves the collection and use of personal privacy information. This value conflict between individual rights and collective interests makes it difficult to balance individual rights and public interests in the application of AI. If not handled properly, it will not only damage the legitimate rights and interests of individuals but also may affect the realization of collective interests, restricting the positive role of AI technology in promoting economic and social development.

4 GOVERNANCE COUNTERMEASURES FOR AI APPLICATION CHALLENGES

4.1 Improve the Legal and Regulatory System and Strengthen Supervision

Laws and regulations are important guarantees for regulating AI application behaviors. A sound legal system can define a reasonable boundary for AI applications and address various challenges[5].

Firstly, accelerate the formulation of special laws and regulations for AI applications, clarify the standardized requirements for the collection, use, and storage of AI data, define the transparency standards for algorithmic decision-making, and prohibit the unfair application of AI technology in fields such as employment and finance. For example, formulate the Regulations on the Management of Artificial Intelligence Applications to clearly stipulate the protection of user data, algorithm transparency, and the protection of employment fairness[6].

Secondly, establish and improve the supervision mechanism for AI applications, set up a special AI supervision agency to conduct full-process supervision over the R&D, application, and promotion of AI technology, increase the penalties for illegal and non-compliant AI applications, and ensure that the application of AI technology complies with legal requirements and public interests.

Finally, promote the construction of industry self-regulation norms, encourage industry associations to formulate AI industry application guidelines, guide enterprises to strengthen self-restraint, establish an internal AI application review mechanism, and conduct compliance assessments on AI products and services to ensure that the application process is legal and compliant.

4.2 Promote the Development of Algorithm Transparency and Interpretability

Algorithm transparency and interpretability are the keys to solving the problem of algorithmic black boxes and addressing algorithm application challenges[7].

Firstly, increase investment in AI algorithm R&D and promote technological innovation in algorithm transparency. Research institutions and enterprises should increase investment in the R&D of Explainable Artificial Intelligence (XAI)

technology, develop AI algorithms with high transparency and interpretability, enable the algorithm decision-making process to be understood and traced by humans, and reduce the risks brought by algorithmic black boxes.
Secondly, establish an algorithm filing and review system, requiring enterprises to file AI algorithms involved in key fields such as finance, employment, and justice and accept reviews by supervision agencies. Supervision agencies organize experts to evaluate the rationality and fairness of the filed algorithms, and require enterprises to rectify problematic algorithms within a time limit to ensure that algorithm applications conform to public interests.
Finally, strengthen education and popular science on algorithm applications to improve the public's understanding and supervision ability of algorithms. The government and enterprises should carry out algorithm popularization activities to popularize the basic principles and application risks of algorithms to the public, enhance the public's awareness of supervising algorithmic decision-making; at the same time, provide professional training for algorithm users to enable them to correctly understand and use algorithms, and avoid application problems caused by misunderstandings of algorithms.

4.3 Strengthen Talent Cultivation and Employment Transformation Support

To address the employment challenges brought by AI applications, the core lies in strengthening talent cultivation and employment transformation support, and improving the skill level and adaptability of workers. Firstly, optimize the education system and strengthen the cultivation of AI-related professionals. Universities should set up majors such as artificial intelligence, data science, and machine learning, optimize curriculum settings, and cultivate AI talents with solid professional knowledge and innovative capabilities; at the same time, integrate AI knowledge into the teaching of traditional majors to enhance students' AI application literacy and interdisciplinary capabilities, laying a foundation for adapting to the needs of the job market in the AI era. Secondly, increase the intensity of skill training for in-service workers to promote employment transformation. The government should increase investment in vocational skill training, establish and improve the vocational skill training system, provide free skill training courses for low-skilled workers replaced by AI, and help them master new skills required in the AI era (such as intelligent manufacturing operations, intelligent customer service management, and basic data analysis) to achieve employment transformation [8]. For example, carry out training on industrial robot operation and maintenance for laid-off workers in the manufacturing industry, and carry out training on e-commerce and online service operation for practitioners in traditional service industries. Finally, encourage enterprises to assume employment responsibilities and provide employment support. Enterprises should establish internal training mechanisms to provide AI technology-related training for employees, helping them improve their skills to meet the needs of enterprise technological innovation; at the same time, enterprises should strengthen cooperation with the government, universities, and vocational training institutions to jointly carry out employment transformation projects, create more job opportunities, and alleviate the pressure on the job market.

4.4 Build a Multi-Stakeholder Collaborative Governance Mechanism

The governance of AI application challenges is a systematic project that requires the collaborative cooperation of multiple subjects such as the government, enterprises, research institutions, social organizations, and the public.
Firstly, the government should play a leading role, formulate the overall strategy and policies for AI application governance, coordinate resources from all parties in a unified manner, and promote the orderly development of governance work. The government should strengthen exchanges and cooperation with other countries and international organizations, participate in the formulation of global AI application governance rules, and promote the formation of unified AI application standards.
Secondly, enterprises should assume the main responsibility and integrate considerations of public interests into the entire process of AI technology R&D and application. Enterprises should establish an internal AI application evaluation mechanism to promptly identify and solve problems in applications; strengthen cooperation with research institutions to jointly develop AI technologies and products that meet social needs.
Thirdly, research institutions should play a technical support role, strengthen research on AI application issues, and provide theoretical and technical support for governance. Research institutions should conduct research on AI application risk assessment and algorithm optimization, and develop technical solutions to solve AI application problems.
Finally, social organizations and the public should play a supervisory role. Social organizations should carry out popular science publicity on AI applications to improve the public's awareness of AI application issues; establish AI application supervision platforms to collect public feedback and promptly report problems to supervision agencies. The public should enhance their awareness of supervision, actively participate in discussions on AI applications, and supervise improper application behaviors to promote the healthy development of AI technology.

5 CONCLUSION AND OUTLOOK

Against the backdrop of technology innovation-driven economic development, AI technology, as a core driving force, brings huge opportunities for economic growth. However, it also faces various challenges in data application, algorithm application, and the job market. Behind these challenges lie value conflicts between efficiency and fairness, innovation and sustainable development, and individual rights and collective interests. If these challenges cannot be effectively addressed and the value conflicts cannot be resolved, the continuous application of AI technology will be restricted, and

the sustainability of economic development will be affected.

Through in-depth analysis of AI application challenges, value conflicts, and governance countermeasures, the following conclusions can be drawn: Firstly, AI application challenges are diverse and complex, involving multiple fields such as data, algorithms, and employment, and need to be comprehensively addressed from multiple dimensions. Secondly, value conflicts are the underlying causes of AI application challenges. Only by balancing the value relationships in different dimensions can the challenges be fundamentally solved. Finally, the governance of AI application challenges requires the collaborative cooperation of multiple subjects. Through measures such as improving laws and regulations, promoting algorithm transparency, strengthening talent cultivation, and building a collaborative governance mechanism, an all-round governance system can be formed to realize the coordinated development of AI technology, economy, and society.

Looking forward to the future, with the continuous innovation of AI technology, its application fields will be further expanded, and new challenges will continue to emerge. Therefore, it is necessary to continuously pay attention to the dynamics of AI applications, strengthen research and exploration on new problems, and constantly optimize governance countermeasures and mechanisms. On the premise of reasonable regulation, AI technology can be promoted to better serve high-quality economic development. At the same time, we should actively participate in global AI application governance cooperation, jointly address global challenges, and promote the formation of a fair and reasonable global AI application governance order.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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TECHNOLOGICAL INNOVATION IN CHINESE OPERA FILMS SINCE THE NEW CENTURY

JingRu Wei
Macau University of Science and Technology, Macao Special Administrative Region 999078, China.

Abstract: As a unique genre of Chinese cinema, opera films have always undertaken the mission of inheriting traditional Chinese culture. Since the new century, the explosive development of digital technology has broken its rigid paradigm of "stage recording" and promoted media reconstruction and aesthetic transformation. This article explores the paths of technological innovation in opera films from three dimensions: technological aesthetics, the integration of 3D/VR/XR technologies, and image empowerment with technological breakthroughs. The findings show that digital technology not only reconstructs the spatial, soundscape and narrative logic of opera, but also revolutionizes the production process, audience-performer relationship and communication field through in-depth integration with emerging technologies. The essence of technological innovation lies in the self-adaptation and proactive evolution of traditional culture in the digital age, with its core being to uphold the ontological aesthetics of opera, find a precise balance between technological rationality and artistic sensibility, and ultimately help opera art achieve creative transformation and innovative development in the contemporary context.
Keywords: Opera films; Digital technology; Technological innovation; Innovative development

1 INTRODUCTION

Chinese opera film is a unique genre in Chinese cinema, and its development trajectory has always been centered on traditional Chinese culture. Evolving alongside the advancement of modern technology, this cross-media art form has embodied a dual mission since its inception: it must not only preserve the stylized aesthetics of traditional Chinese opera, including its singing, recitation, acting, and acrobatics (collectively known as "chang, nian, zuo, da" in Chinese opera terminology), but also adapt to the narrative characteristics of film' s camera language. Chinese opera film is thus a product of the symbiotic integration of these two artistic forms that operate on parallel paths. The virtuality and stylized performance of opera collide and merge with the realism and documentary nature of film, forging the unique presentation style and aesthetic traits of Chinese opera film.

Since the new century (i.e., since 2000), the rapid development of digital technology has endowed this symbiotic relationship with a new dimension of interpretation. When HDR technology—with its expanded dynamic range—digitally enhances the colors of opera costumes; when action cameras and motion capture technology reconstruct the postures and movement trajectories of martial arts performers in opera; when virtual production materializes the abstract imagery in opera; and when stereophonic sound fields create a surround effect for virtual stages, the rigid "stage recording" paradigm that once defined the creation of Chinese opera film has been quietly broken by technological progress. In this new era, technology has begun to question the ontological essence of Chinese opera film. What new technology enables is not merely a simple additive application of technical tools, but a media reconstruction with cultural production significance that aligns with the core logic of remediation theory. Specifically, digital film—this "new medium"—creatively reshapes the expressive forms and perceptual dimensions of opera while preserving the core aesthetic traits of opera as an "old medium."

In Chinese opera films of the new century, the application of digital technology has not only transformed the way these films are created and presented, but also redefined the existential form of "operatic nature" without diluting the essence of opera. For instance, 120-frames-per-second slow-motion photography extends the time and space of unique opera sequences such as feather fan techniques and water sleeve movements. It converts the subtle, fleeting details that audiences once had to "catch from a distance" and "perceive through imagination" on traditional stages into clearly observable, delicate movement trajectories on the screen, allowing the rhythmic and technical nuances of operatic stylization to be presented more intuitively. The integration of Dolby Atmos has broken the limitation of the "single sound field" on traditional opera stages; it deconstructs and reorganizes the timbres of traditional instruments like the jinghu (a two-stringed fiddle unique to Peking Opera) and banhu (a high-pitched bowed string instrument widely used in Chinese folk operas) within an auditory space, creating an immersive surround sound experience and endowing the layered texture and expressive power of opera music with a new dimension of expression. The new grammatical system of Chinese opera film constructed collectively by these technical elements is, in essence, the remediation of opera art through the medium of digital film.

Technological upgrading has driven the systematic reconstruction of the production ecosystem, which is mainly reflected in the interactive matrix of production processes, narrative dimensions, and reception arenas. For example, virtual production technology has broken the linear production model of traditional Chinese opera films—where "stage performance comes first, followed by filming"—and this technological innovation has addressed the issue of relative

separation between stage space and camera space that once existed in traditional Chinese opera films. From an industrial development perspective, technological empowerment can also reduce the production costs of Chinese opera films, improve production efficiency, and expand market share. “The integration of digital technologies has simplified the overall production workflow of traditional Chinese opera films while boosting operational efficiency[1].” Diverse communication channels and marketing methods have also provided more opportunities for the market promotion of Chinese opera films. As an important contemporary carrier for the dissemination of opera art, Chinese opera film needs to leverage technological means to achieve modern transformation, thereby promoting the broader dissemination, inheritance, and development of opera art.

2 Technological Aesthetics of Chinese Opera Films Since the New Century

Traditional opera art features highly stylized aesthetic characteristics, with its performance, singing, and other elements following strict norms and conventions. However, against the backdrop of a modern society with diverse cultures, this aesthetic paradigm is facing a disconnect from the aesthetic concepts of contemporary audiences. The involvement of digital technology has broken the single stylized aesthetic model of opera art, promoting its development toward a more diversified aesthetic direction and reconnecting traditional aesthetics with modern concepts.In the historical context of the new century, the technological revolution, like a powerful engine, has driven the iterative transformation of Chinese opera films in terms of aesthetics. 2019 film Catching and Releasing Cao became the world' s first 8K Peking Opera film with panoramic sound. Through ultra-high-definition images and rich sound effects, the film offered an unprecedented viewing experience. This work not only preserves the classical Peking Opera performance but also enriches its artistic expression through modern technology, opening new possibilities for the future of Chinese opera films[2]. This has not only rewritten the industrial production paradigm of films but also left the mark of the times in the creative and production process of Chinese opera films. Different from other film genres, Chinese opera films must not only uphold the traditional artistic genes of opera but also reconstruct the screen' s expressive language through digital technology. This aesthetic evolution is not a one-way transformation of the art; instead, it fosters a new aesthetic form that integrates the expressive language of opera art with the contemporary visual context.

2.1 The Reconstruction of Opera Space Through Digital Technology

Since the turn of the new century, digital technology has intervened in the field of Chinese opera film with unprecedented force, triggering profound transformations in the aesthetic space of Chinese opera. “The cinematic translation of stage concepts is not only intended to integrate with the stage art of traditional opera, but more importantly, to create a kind of beauty that can resonate emotionally with the audience[3].” The technical and aesthetic transformation of Chinese opera film is, in essence, a cinematic translation of the assumptive aesthetics of traditional Chinese opera. Technology reshapes the original aesthetic space of Chinese opera, gives rise to new artistic forms and aesthetic experiences, breaks the physical boundaries of the traditional Chinese opera stage space, expands the expressive dimensions of performances, and reconstructs the temporal and spatial logic of narration—allowing Chinese opera film to exhibit entirely new aesthetic characteristics through the integration of technology and art. The aesthetic principle of "using virtuality to represent reality" in traditional Chinese opera has been reinterpreted with the support of digital technology; in terms of audio-visual language, the rapid development of digital technology has also brought boundless possibilities for showcasing the charm of Chinese opera art.

Constrained by film shooting methods and optical processing technologies, traditional Chinese opera films had limitations in image clarity, color richness, and scene construction. The emergence of digital technology, however, has broken these original constraints throughout the pre-production, production, and post-production stages of Chinese opera film creation. Digital cinematography can accurately capture the vivid expressions of opera performers and their body language with narrative and expressive significance, conveying the unique "freehand" beauty of Chinese opera to audiences in a more delicate manner. The traditional "one table and two chairs" stage space has undergone a paradigm shift from a "two-dimensional" to a "three-dimensional" form through digital technology; the narrative dimension has also evolved from linear to three-dimensional, and from single-faceted to diverse. The reconstruction of Chinese opera' s narrative space by digital technology is also reflected in the detailed depiction of scenes and the creation of atmospheres. High-precision digital modeling and light rendering enable scene details and atmosphere to reach a level of refinement that traditional stages could hardly achieve—this not only enhances the sense of realism and immersion in narration but also endows Chinese opera film with more diverse aesthetic expressions.

The aesthetic space of Chinese opera reconstructed by digital technology represents the "diversified manifestations" of traditional art in the digital era. Breaking down and reconstructing existing concepts not only preserves the original essence of Chinese opera as "telling stories through singing and dancing" but also expands its expressive timeline through technical media. When Chinese opera film reconstructs its aesthetic space in the digital dimension, it not only accomplishes the media transition from stage to screen but also achieves a creative transformation from the aesthetic paradigm of agricultural civilization to the aesthetic system of the digital age. However, technical reconstruction also harbors aesthetic risks: excessive intervention of digital effects in the core of performances may dilute the fundamental value of Chinese opera, which lies in "driving the story through performers"; when immersive experience replaces aesthetic distance, it may weaken the philosophical implication of "calm observation and quiet contemplation" in

Chinese opera. Therefore, creators must maintain aesthetic awareness toward traditional culture in the application of technology.

2.2 Application of Spatial Montage in Opera Films from the Perspective of Technological Aesthetics

Before the involvement of digital technology, the spatial aesthetics of opera films were constrained by the dual opposition between "stage recording" and "film grammar". The spatial design of traditional opera stages adheres to the aesthetic principles of "virtuality, stylization, and impressionism", where the narrative space is co-constructed by the performers' actions and the audience' s imagination. The integration of digital technology, however, has enabled opera films to break free from physical limitations in spatial expression, creating a "beyond-stage" visual spectacle.

Early opera films mostly relied on medium shots with fixed camera positions, attempting to replicate the "fourth wall"—an inherent element of the traditional audience-performer relationship—in the two-dimensional screen. While this replicative approach preserved the integrity of opera art, it failed to achieve an organic fusion of the two art forms. In the 3D spatial audio opera film Farewell My Concubine, digital technology transforms the historical scenes of the Chu-Han rivalry into a rotatable and penetrable three-dimensional space. During Yu Ji' s sword dance sequence, the combination of dynamic camera movements and virtual scenes extends the traditional "circular stepping" technique into an epic visual trajectory within the 3D space. This technical treatment is not a mere copy of stage performance; instead, it converts the "linear timeline" of opera performance into a "three-dimensional spatial field" through spatial montage. The close-up shots of Xiang Yu and Yu Ji toasting for the last time allow the audience to clearly see the tears welling up in their eyes—a detail never before so vividly presented. This "single tear" in Farewell My Concubine symbolizes a new horizon for the "new Peking Opera film" genre.

Technological empowerment has also facilitated in-depth integration between the stylized virtuality of opera and the spatial montage thinking of film. In the Cantonese opera film The Legend of the White Snake, post-production special effects turn the stylized "water sleeves" (a traditional opera prop) into a concrete digital torrent. “The film presents the digital "ink wash-style Chinese aesthetics[4].” A milestone of new-age xiqu cinema, White Snake actively responds to the changing circumstances of emerging technologies and young people' s zeal for traditional culture, blurring the boundary between revered heritage and popular cultural product[5]. The support of IMAX technology further enhances the immersive quality of spatial montage in opera films. For instance, in the Peking Opera film Cao Cao and Yang Xiu, IMAX' s ultra-large format showcases the grand space of Cao Cao' s military tent, while a rapid zoom-in shot focuses on the bamboo slips in Yang Xiu' s hands—these slips then transform into swirling snowflakes. The camera then pulls back to reveal a snowstorm-shrouded ancient battlefield. This spatial transition from micro to macro breaks the distance between audience and stage in traditional opera, allowing viewers to both catch the subtle facial expressions of performers and feel the grandeur of the battlefield.

Spatial montage empowered by technology elevates opera performance from "linear narration" to "spatial poetics" while preserving the essence of stylized aesthetics, thus achieving the creative transformation of traditional art. Here, spatial montage serves not only as a narrative tool but also as an aesthetic strategy to reshape the audience-performer relationship in opera films. This technical practice also validates Marshall McLuhan' s theory of "the medium is the message": digital technology not only changes the presentation form of opera films but also reshapes their aesthetic essence—transforming the "distant virtual stylization" of opera into a tangible "immersive aesthetics" that the audience can perceive directly.

The evolutionary path of technological aesthetics reveals the dual dimensions of space in opera films: horizontally, digital technology breaks down the physical boundaries between stage and screen, and the resetting of media interfaces enables the multi-dimensional deconstruction and reorganization of stylized performances; vertically, the construction of immersive fields integrates the audience into the narrative system of opera films, achieving a paradigm shift in aesthetics from "alienation between audience and performance" to "emotional immersion" through the technical extension of synaesthesia. This represents opera films' reaffirmation of their own artistic essence in the digital age of the 21st century. When the stylized virtuality of opera meets the digital space of film, the sparks generated open up new narrative possibilities for opera art in the context of technological reconstruction.

Practice of opera films since the 21st century has shown that the application of spatial montage is not a deviation from opera aesthetics, but rather a balance struck between technical rationality and artistic sensibility. In terms of technological empowerment, films leverage advanced technologies to bring out the delicate details of Kunqu opera aesthetics. 8K ultra-high-definition technology presents subtle details that are easily overlooked on stage—such as the curvature of water sleeves, changes in finger movements, facial expressions (e.g., Lu Sheng' s tipsy look in his dream and his realization upon waking), clothing patterns, and the texture of props—turning the Kunqu principle of "conveying spirit through form" from an abstract perception into an intuitive visual experience. Spatial audio technology accurately reproduces the layered vocal expressions of Kunqu (including the singer' s breath and the timbre of musical instruments) as well as environmental sounds, avoiding the audio overlap issues common in traditional productions. Furthermore, it uses spatial sound to guide emotions, allowing the "emotion transmission through vocals"—a unique feature of Kunqu—to transcend the auditory dimension and achieve dual audio-visual immersion.

When digital technology can accurately capture the graceful trajectory of water sleeves, and when moving shots can perfectly present the acrobatic movements in martial scenes, the spatial narration of opera films is undergoing an aesthetic leap from "reproducing the stage" to "creating the screen". This leap requires both a deep understanding of

opera traditions and the creative application of film technology. Only through the positive interaction between the two can the artistic realm of "technology serving opera, and aesthetics renewed by technology" be truly realized. The development of spatial montage not only demonstrates the technological progress of opera films but also reflects the cultural awareness of traditional art in its self-renewal during the digital era.

2.3 Aesthetic Modal Transformation of Soundscape Engineering and Opera Rhythm

The tide of technology is impacting the field of film and television art with unprecedented force, and opera films—an unique artistic form embodying traditional opera culture and modern film-television technology — are constantly undergoing the transformation of aesthetic paradigms. As a key technical manifestation of the film industry in the digital age, soundscape engineering' s collision and integration with opera rhythm form a crucial entry point for understanding the aesthetic transformation of contemporary opera films. Traditional opera is a comprehensive art based on "telling stories through singing and dancing," with its core sound system including arias, recitatives, accompaniment by civil and military orchestras, and stage effect sounds, forming the unique rhythmic aesthetics of opera. Its sound presentation often follows the acoustic spatial aesthetic principles of opera stages, emphasizing "freehand brushwork" and "stylization." Arias pursue "clear articulation and mellow tone" and "expressing emotion through sound," with each segment bearing the functions of character emotional expression and plot advancement. Its rhythmic patterns are closely linked to opera' s beat patterns, forming a fixed yet elegant framework. Constrained by the two-dimensional flatness of physical venues, the soundscape construction of traditional opera stages has always wandered and changed along the axis of "stage entrance-audience seating." Multi-channel recording technology in soundscape engineering is an emerging technical field integrating acoustics, psychology, aesthetics and other disciplines. It collects different sound sources through multiple microphone positions and conducts precise spatial positioning and mixing in post-production; “The advent of Dolby Atmos has freed auditory effects from mere dependence on visual presentation, allowing them to exist as a more authentic and immersive relay element within the film[6].” The Peking Opera film Cao Cao and Yang Xiu has adopted a full set of state-of-the-art Dolby Atmos production workflows, and engaged Roger Savage—an Oscar-winning British sound production master — to oversee the Dolby Atmos sound design[7]. The soundfield positioning of the traditional "Three Major Instruments" ensemble has been transformed into the distribution of a 3D soundscape particle map, while the original fixed instrumental tracks have evolved into a rhythmic matrix of independent tracks surrounding the audience. This acoustic technological innovation does not deviate from the intrinsic aesthetics of traditional opera art; instead, it leverages digital technologies for sound image displacement to control and regulate the audio, creating a more three-dimensional auditory space for the "Xipi and Erhuang" arias within the metric structure of Peking Opera. It not only preserves the traditional charm of opera but also aligns with the rhythmic logic of film narrative.

Soundscape engineering can also creatively combine and process different sound materials to realize the innovative expression of opera rhythm. For example, in wind and rain scenes, realistic wind and rain sounds blend with arias and accompaniment, enhancing artistic appeal and immersion; rhythmic changes based on fixed beat patterns and performance modes break traditional rigid frameworks, offering unlimited possibilities for the richness of opera rhythm. In the soundtrack of the Cantonese opera film The Legend of the White Snake, modern electronic sounds interweave with the timbres of traditional instruments such as the gaohu and yehu. While preserving the metrical rules of opera music, it creates a soundscape conforming to modern aesthetics, breaking through "protectionist" thinking and integrating historical charm with new-era aesthetics. This soundscape revolution goes beyond the superficial significance of technical upgrading, allowing the audience to hear the frequency of technological innovation while truly feeling the resonance of inheriting fine traditional Chinese culture in the interweaving of virtual and real soundscapes. The rhythmic transformation driven by soundscape engineering triggers dual effects at the aesthetic level: digital technology expands the expressive dimensions of opera vocals, endowing traditional recitatives with new spatial narrative capabilities in the panoramic sound field; at the same time, excessive technical processing may lead to opera aesthetics becoming a subsidiary of "sound effects." As Dolby Atmos reshapes the acoustic dimensions of "Xipi" and "Erhuang" tunes, and AI algorithms deconstruct the pronunciation rules of "four articulation methods and five vowel categories," opera films are undergoing an aesthetic transformation from "stage recording" to "acoustic installation." Practitioners of opera films must maintain reverence for the essence of opera while transcending technological determinism, exploring paths for the modern transformation of traditional art in the gap of modal transformation. Future soundscape design of opera films may open up a "new vocal" aesthetic system belonging to the digital age through the balance between technical rationality and artistic poetry.

In the digital era, the audience' s aesthetic needs present diverse and personalized characteristics. They pursue fresh and exciting visual experiences, emphasizing emotional resonance and interactivity. Through innovative creation of opera films, digital technology accurately meets these aesthetic needs of modern audiences. Technology-driven aesthetic transformation is a process of reconstructing artistic ontology by digital media. Opera films are no longer confined to the simple superposition of "combining opera with film" through cinematic forms; instead, under the combined effect of technology, creation and even algorithms, they have spawned a third-state artistic form with digital aura. This transformation not only inherits Mr. Mei Lanfang' s innovative spirit of "moving forward without changing essence" but also uses technology as a fulcrum to promote the modern transformation of the entire aesthetic system of opera art.

3 Technological Integration of Opera Films with 3D/VR/XR

Since the new century, the iteration and upgrading of digital technology have opened up multi-dimensional paths for the development of opera films. When technologies such as 3D, VR (Virtual Reality), and XR (Extended Reality) meet opera art, they not only trigger innovations in creative tools and presentation forms but also drive the in-depth reconstruction of opera films from the audio-visual language system to the audience-performer relationship. This technological integration explores the transformation possibilities of traditional opera art in contemporary audio-visual space through the collision between the aesthetic characteristics of opera and the properties of digital technology. What audiences perceive in three-dimensional images is not only the expansion of spatial dimensions but also the digital extension of the free nature of opera's time and space.

3.1 3D Technology: A Spatial Dialogue Between Stereoscopic Imaging and Traditional Opera Conventions

The spatial presentation of traditional opera films has long grappled with the dual tension between the operatic stage nature and the cinematic camera perspective. Since the birth of Dingjun Mountain in 1905, opera films have constantly sought a balance between "stage recording" and "cinematic adaptation." Early works mostly adopted fixed-camera stage documentation, with spatial movement confined by the physical boundaries of the theater. After the founding of New China, films such as Legend of the White Snake (1956) attempted to deconstruct the stage structure through montage, breaking free from temporal and spatial limitations. However, the two-dimensional flat image carrier still struggled to fully convey the spatial poetics of opera performances—virtual spaces constructed through stylized movements (e.g., "horse-trotting" gestures symbolizing a long journey, whip-flicking representing riding) often lost their freehand artistic qualities when concretized in real shooting scenes.

The introduction of 3D technology first revolutionizes opera films through breakthroughs in spatial dimensions. Traditional opera films, restricted by the physical boundaries of the flat screen, usually express stage space symbolically through axis movement and depth-of-field shots. In contrast, 3D technology, based on the principle of binocular parallax, transforms the virtual time and space of opera into a perceptible three-dimensional field. This transformation is not a mechanical reproduction of the stage space but a creative translation of opera' s aesthetic characteristics enabled by digital technology. The technical features interact subtly with the virtuality of opera performances: the three-dimensional image space not only enhances the visual impact of operatic movements—for example, acrobatic skills like somersaults and spins in Peking Opera martial scenes gain more striking dynamic expressions through 3D effects—but digital modeling also allows creators to construct interwoven virtual-real spatial scenes according to narrative needs. The digital reproduction of the opera stage in the 3D opera film Xiao He Chases Han Xin Under the Moon creates a surreal symbolic space using CG technology.

This three-dimensional reconstruction of spatial narration is essentially a contemporary interpretation of Bazin' s theory that "cinema is an asymptote of reality," reconciling the "alienation effect" of opera performances with the "immersive experience" of cinema. Technologically empowered spatial narration does not diminish the virtuality of opera; instead, through three-dimensional visual language, it establishes new visual logic for stylized virtual movements in a three-dimensional space. Meanwhile, the real physical space is elevated into a poetic image space by the freehand spirit of opera.

3.2 VR Technology: A Perceptual Revolution in Audience-Performer Relations and Immersive Experiences

If 3D technology represents the vertical expansion of screen space, VR (Virtual Reality) technology eliminates the "fourth wall" of traditional viewing spaces and constructs a fully immersive interactive environment. Through virtual theaters created by head-mounted displays, VR technology breaks the physical barrier in traditional audience-performer relationships, allowing audiences to achieve a "front-row" immersive experience in cyberspace. Its core features are "presence" and "interactivity." The integration of VR technology transforms opera films from "an art of viewing" to "an art of experience," a shift that poses a fundamental challenge to the traditional audience-performer dynamic of opera. Audiences evolve from passive observers in front of the screen to "present participants" in virtual scenarios, and this revolution in audience-performer relations prompts a rethinking of the essence of opera films.

In immersive experiences, audiences gain subjective and multi-dimensional perspectives of the opera stage, deconstructing the limitations of camera angles in traditional opera films. They can even interact with virtual props (such as tables and chairs on the stage, or rockeries in gardens) through controller operations. The transformation of audience-performer relations inevitably leads to adjustments in narrative strategies—details that might be overlooked in traditional camera shots become crucial for conveying the narrative tension of opera under VR' s close-up observation. While traditional opera films rely on directors' cinematographic language to guide audience attention, VR narratives require the construction of open spatial narrative structures, where interactive designs grant audiences limited participation in the narrative. Through haptic feedback devices and motion capture systems, VR technology enables audiences to obtain an embodied perceptual experience similar to watching a live opera performance. When a character performs a stylized "freeze" move like a stance, audiences can feel the vibration of the ground through haptic feedback; in martial arts scenes, the sound of clashing weapons changes direction with the rotation of the audience' s head. The synergy of these multi-sensory perceptions transforms the "symbolism" of opera performance into tangible bodily memories through digital technology, realizing the identity shift of "audience as performer" in virtual space.

The "stylization" of opera performance faces dual challenges in VR spaces. Technology' s impact on opera films extends beyond the form of viewing and performance to touch the core realm of opera aesthetics. High-precision

motion capture technology can perfectly reproduce performers' stylized movements, such as water sleeve and beard techniques, and even allow audiences to "feel" the weight of water sleeves through force-feedback gloves. However, fully immersive virtual scenarios may obscure the traditional "conventionality" inherent in opera—when a virtual garden is more exquisite than a real one, and a digital avatar is more perfect than the performer themselves, will the aesthetic space of opera, built on imagination, be replaced by the "reality" constructed by technology?

From the perspective of reception aesthetics, VR opera films are cultivating the aesthetic cognition of a new generation of audiences. For Generation Z, the viewing mode that requires active exploration aligns better with the behavioral habits they developed through digital games. This cognitive transformation is not only a technological innovation but also an important path for the intergenerational inheritance of opera art in the digital age.

3.3 XR Technology: The Coexistence of Reality and Virtuality in Traditional Chinese Opera

XR (Extended Reality), as a technological integration integrating AR (Augmented Reality), VR (Virtual Reality), and MR (Mixed Reality), is breaking the inherent boundaries of traditional media, creating cross-dimensional narrative possibilities for traditional Chinese opera films. If 3D represents the vertical extension of screen space and VR the construction of enclosed virtual spaces, XR is committed to breaking down the barriers between the real and virtual worlds. It allows traditional opera art to intervene in the viewer's real world in a more extensible form, overlaying virtual opera elements onto real scenes to build a mixed reality theater where reality and virtuality converge. This not only expands the communication field of traditional opera films but also opens up new channels for cultural inheritance.

The innovation of XR technology in reshaping the creative paradigm of traditional opera films is also reflected in the practice of "Transmedia Storytelling." Traditional opera films are closed narrative texts, while XR-based opera works have become open narrative systems. XR technology promotes a shift from "director-centered" to "user-centered" approaches in opera films, emphasizing the process of embodied cognition. It transforms the linear, preset creative process of traditional films; XR works need to preset multiple interactive paths and consider the impact of user behavior on narratives. This requires creators to possess "spatial narrative thinking," converting the temporal narration of opera into spatial experiences.

In the field of cultural heritage preservation, XR technology has enabled the "digital rebirth" of traditional opera art. Through laser scanning and motion capture technologies, performance data of master artists like Mei Lanfang have been transformed into interactive digital models. The XR Opera Exhibition launched by the Chinese Opera Museum creates a fantasy "stage" through virtual reality and integrates "hundreds of operas" with digital light and shadow, expanding new scenarios of "metaverse + opera." By combining classic opera elements with national animation, it presents traditional cultural stories in a dreamlike wonderland. Visitors can immerse themselves in the vivid oriental aesthetics within the "pavilions and towers" of the museum. Technological practices have transformed the "museum-style" preservation of opera art into "dynamic inheritance," reconstructing the inheritance mechanism of cultural memory in cyberspace. When digital technology can revive the stage images of deceased artists and AI can simulate the vocal characteristics of genre founders, the "dynamic inheritance" of opera has gained new technological carriers. At the same time, it raises ethical discussions about artistic authenticity: Do virtually generated performances belong to opera inheritance? Can technically replicated vocals carry the spiritual core of artistic genres?

Traditional Chinese opera is "telling stories through singing and dancing," with its aesthetic core lying in the organic unity of stylization, virtuality, and impressionism. The sensory stimulation brought by 3D/VR/XR technologies, if separated from the aesthetic foundation of opera, will ultimately become empty technological displays. As Walter Benjamin warned in "The Work of Art in the Age of Mechanical Reproduction," technological reproduction may dissolve the "aura" of art, but it also creates possibilities for art popularization. The key lies in maintaining the "ontological awareness" of opera amid technological innovation. Such awareness first manifests in adhering to the subjectivity of opera performance—no matter how technology develops, the physical expression of actors remains the core of traditional opera films. The virtuality of opera essentially "uses simplicity to replace complexity"; excessive stacking of digital effects may violate the impressionistic spirit of opera. In creating virtual opera, insisting on using real actors for motion capture instead of relying on CG generation is precisely to preserve the "dynamic" characteristics of opera performance. The curvature of Cheng Yanqiu's water sleeves and the flow of Mei Lanfang's eye expressions—these subtle, personalized differences are important carriers of the "aura" in opera art. Technology should serve as a tool to amplify this "aura" rather than replace actors.

At the intersection of technology and art, the development of traditional opera films presents unprecedented possibilities. 3D/VR/XR technologies not only change the presentation of opera but also reshape the audience's cognitive paradigm: from flat viewing to three-dimensional experience, from passive acceptance to active exploration, from screen watching to field immersion. However, all technological innovations must answer a fundamental question: When all digital effects are removed, does the work still carry the spiritual essence of opera art? Only by maintaining a dynamic balance between technological empowerment and ontological adherence can traditional opera films continue the artistic legend of "moving forward without changing essence" in the digital age. This balance is not a simple compromise but a creative transformation based on a deep understanding of opera aesthetics—allowing the ancient art of opera to grow into a new form that retains its genetic characteristics while embracing the times in the soil of new technologies.

Technological integration should not be limited to formal innovation but should touch upon the cultural functions of traditional opera films. The ultimate value of technology lies in activating the contemporary interpretive power of opera. As reflected in the overseas acclaim for technologically integrated opera films such as The Monkey King and Farewell

My Concubine, technologically empowered opera films are not only carriers for preserving traditional culture but also media for cross-cultural dialogue. When Western audiences understand not just an opera story but the philosophical wisdom of "using virtuality to represent reality" in Chinese opera, the true value of such integration is realized.

4 Visual Empowerment and Technological Breakthroughs of Traditional Opera Films

With the involvement of digital technology, traditional opera films have undergone an in-depth transformation from creative concepts to practical paradigms amid the wave of digital advancement. The reconstruction of opera images, the renewal of aesthetic perceptions and the reform of communication methods have endowed the traditional opera art with new vitality in the digital era.When the stage aesthetics of traditional opera encounter the technical logic of the film industry, their collision gives birth to a unique artistic form that is neither a mechanical reproduction of the opera stage nor a blind accommodation to film language. Empowered by technology, films have achieved the visual reconstruction of the essence of traditional opera.This reconstruction is reflected not only in the upgrading of shooting techniques but also in the paradigmatic shift of artistic thinking. Digital technology is no longer a mere instrumental carrier; instead, it deeply integrates into the narrative strategies, aesthetic expressions and communication logic of traditional opera films. While preserving the freehand spirit of traditional opera, it endows the art form with visual appeal that suits the modern viewing context.The use of digital technology is not only a technological advancement but also a revolution inaesthetics. With the help of digital technology, filmmakers are able to explore more narrative techniques and visual styles, such as virtual reality, augmented reality, and other emerging technologies, which bring unprecedented aesthetic innovation possibilities for Chinese films[8].

4.1 Modern Transformation of Traditional Opera Empowered by Digital Technology

Since the new century, the rapid advancement of digital technology has driven drastic morphological changes in traditional opera films. This technological revolution has not only restructured the ontological attributes of images in traditional opera films, but also profoundly transformed the contemporary communication paradigm of traditional opera art, realizing the ontological reconstruction and cultural value increment of traditional opera art through visual images.

With the integrated application of high-definition and high-speed photography technology, motion capture technology, and the upgrading of projection equipment, cutting-edge technologies have been widely adopted in opera films. For the Cantonese opera film Legend of the White Snake · Love, the production team used 240 frames per second slow-motion photography to capture the performers' water sleeve movements and created digital trails with ink wash textures through particle effects. The fluttering of water sleeves at the cuffs, the swaying of tassels on sword hilts, and even the subtle twitches of facial muscles are clearly presented. The "artistic conception" that relied on the audience's imagination to complement on the traditional stage has been transformed into directly perceptible "visual imagery" in high-definition images.

The Peking opera film Cao Cao and Yang Xiu, remade 30 years later as a 3D + 4K panoramic sound work, adopted full-process 3D live-action shooting technology, marking the first 3D panoramic sound 4K film produced in an end-to-end manner by SMG. The film achieved contextual dialogue between traditional Chinese culture and mainstream Western culture, making 3D panoramic sound opera films a calling card of Shanghai's cultural brands. A growing number of opera films are also combining high-definition photography with panoramic sound to present the modern charm of opera art in an all-round and immersive way. This transformation of performance paradigm is essentially the video-oriented adaptation of opera's essence empowered by technology: it retains the core aesthetic elements of singing, reciting, acting and fighting, while endowing them with more modern visual interpretations through cinematic techniques.

Technological practices have not only restructured the spatial narrative logic of opera films, but also explored new paths for the visualization of operas in the digital age through the visual language that integrates virtuality and reality. Two Cantonese opera films, The Legendary Top Scholar Lun Wenxu and Liu Yi's Adventure, boldly introduced LED technology and dynamic effect technology in scene setting. During filming, dynamic simulated backgrounds were used to incorporate the snow scenery of northern China, the mountain views of southern China, the magnificent underwater dragon palace buildings, and the beautiful landscapes of Guangdong into the images. The production team consciously controlled the realism of the special effects, enabling performers to balance their body movements and dance while realizing innovations in film language. The presentation that blends 80% realism with 20% imagination not only preserves the freehand charm of traditional opera art, but also endows the images with a poetic and romantic atmosphere.

As mentioned earlier, the opera film Madam An Guo, which adopted LED virtual production technology, transformed the traditional opera convention of "performers entering and exiting the stage from side doors" into an interactive digital space. This filming mode of "co-existing virtual and real elements" has not only resolved the long-standing imbalance between stage sense and cinematic sense in opera films, but also achieved in-depth integration of traditional opera stages with modern digital film technology, creating an unprecedented immersive aesthetic experience for traditional opera.

The technological practice of Madam An Guo shows that digital technology is not an opposite to opera aesthetics, but a carrier for the evolution of traditional artistic genes in the contemporary media environment. While expanding the expressive boundaries of opera films, technological innovation also inspires us that the contemporary transformation of

traditional art in the digital age must be based on a profound understanding of media characteristics. Only through the collaborative innovation of technological logic and artistic logic can the creative inheritance of cultural genes be achieved.

4.2 AI Technology' s Transformations to the Creative System of Traditional Opera Films

As digital technologies restructure the global film and television landscape, the integration of artificial intelligence (AI) is reshaping the paradigms of traditional artistic creation at an unprecedented pace. Traditional opera films, a crucial carrier of Chinese aesthetic spirit, are undergoing a profound transformation in their creative system—shifting from mere "technical assistance" to fundamental "cognitive reconstruction". This transformation manifests not only in the digital upgrading of production processes but also in a paradigmatic shift at the level of artistic ontology.

The shooting of the 8K Peking Opera film The Legend of the Concubine of the Tang Dynasty stands as an explorative practice that upholds traditions while pursuing innovations. By inputting the stylized norms for martial arts sequences in traditional operas, the AI system can automatically generate martial arts choreographies that conform to opera aesthetics and possess cinematic expressiveness. This technological application not only enhances creative efficiency but, more importantly, establishes a conversion interface between traditional stylization and modern imagery, providing a new methodology for the modern transformation of traditional opera films.

AI' s application in this field extends beyond the creation of new works; it also plays an indispensable role in restoring classic traditional opera films. Beijing University of Posts and Telecommunications has launched an cutting-edge micro-course themed "When Classic Peking Opera Films Meet AI". During the course, teachers and students utilized AI technology to restore and recreate a 1956 film, allowing Cheng Yanqiu—who starred in the original work at 52—to appear on screen as a young man.

Emotional expression in traditional opera performances has always relied on performers' physical control and artistic perception. AI now attempts to analyze and replicate this intricate psycho-physiological mechanism through affective computing technology. Essentially, the transformations brought by AI to the creative system of traditional opera films represent a collision between technological rationality and artistic sensibility. On one hand, the integration of algorithms boosts creative efficiency, expands expressive boundaries, and paves new ways for the modernization of traditional opera. On the other hand, excessive reliance on technology may diminish the initiative of creative subjects, erode the vivid texture of stylized performances, and even endanger the cultural roots of traditional opera art.

Currently, AI technology is applied in traditional opera films through a collaborative empowerment model. Traditional culture and its long-standing inheritance will not vanish with the emergence of new technologies; instead, they should radiate new vitality for the contemporary era with technological support. The transformations AI brings to the creative system of traditional opera films actually involve a reconstruction of the core questions: "What constitutes traditional opera?" and "What constitutes film?"

As AI algorithms start to decode the performance essence embedded in the "Four Performing Skills and Five Basic Methods", and as deep learning models attempt to simulate the underlying logic of opera aesthetics, we witness both the remarkable possibilities brought by technological revolution and the profound challenges at the level of artistic ontology. This transformation is not a mere technological upgrade, but an all-round restructuring of the entire creative system—from material foundations to value perceptions.

Technology serves as a means, while art remains the ultimate goal. In the application of AI, we must guard against the mindset of prioritizing data excessively and adhere to the inherent characteristics of traditional opera art. Whether it is stylized movements in virtual scenes or algorithm-generated arias and librettos, all should always aim to convey emotions and meanings, striking a balance between technological innovation and artistic rules.

From the modern translation of opera stylizations via digital images, to the multi-dimensional expansion of audience reception paradigms through sensory technologies, and further to AI' s in-depth involvement in the creative system, technological innovation is reshaping the artistic essence and cultural identity of traditional opera films in the digital age. Future creation of traditional opera films will continuously explore the balance between technological rationality and artistic lyricism within the symbiotic relationship of human-machine collaboration.

5 CONCLUSION

Since the new century, digital technology has propelled traditional opera films to achieve crucial leaps and systematic innovations. It has successfully established a technological aesthetic system that integrates the core aesthetics of traditional opera with modern modes of expression, opening up brand-new horizons for creative practices.

However, technology is inherently a double-edged sword. For the future innovation of traditional opera films, on the basis of deepening the integration of art and technology, we must always adhere to the core principle of taking traditional aesthetics as the foundation and the essence of traditional opera as the core, and resolutely avoid the trap of employing technology merely for its own sake.

Meanwhile, we should actively explore diverse application scenarios for new technologies. While firmly safeguarding the cultural roots, we need to accurately meet the aesthetic demands of contemporary audiences and earnestly fulfill the contemporary mission of cultural inheritance and cross-cultural communication. Ultimately, this will realize the creative transformation and innovative development of traditional opera art, enabling traditional opera films to become an important carrier for conveying the spirit of Chinese aesthetics and core cultural values.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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FROM THE SPATIAL TURN TO GEOGRAPHICAL ONTOLOGY: THE DEVELOPMENT OF CHINESE LITERARY GEOGRAPHY

Li Gu
School of International Studies/Center for Southeast Asian Studies, South China Normal University, Guangzhou 510631, Guangdong, China.

Abstract: This article analyzes the formation and theoretical development of Chinese Literary Geography. It places this field within the global intellectual shift towards spatial analysis, known as the "Spatial Turn." The study outlines a central tension shaping the discipline between two approaches: the "Geographical Perspective," influenced by Western theories of space, power, and representation, and the "Literary Perspective," grounded in traditional Chinese methods of mapping authors and regional literary history. The article follows the field's philosophical progression, noting its move from a human-centered view to a "Geographical Ontology" that emphasizes the fundamental material relationship between people and their environment as a basis for literature. In terms of method, it assesses how Chinese scholars have applied and adapted Western frameworks like Geocriticism, Imaginative Geographies, and digital literary mapping to bridge detailed textual study with broader pattern analysis. The argument concludes that the path forward for Chinese Literary Geography is through a deliberate synthesis of its diverse traditions. This "New Literary Geography" aims to combine empirical research with spatial theory, focusing on the literary text as the core site where geographical reality is constructed and transformed.
Keywords: Chinese Literary Geography; Spatial Turn; Geographical Ontology; Geocriticism, Literary Cartography; Man-earth relationship

1 INTRODUCTION: THE SPATIAL TURN AND THE REORIENTATION OF CRITICAL INQUIRY

The study of humanities in recent decades has been profoundly shaped by a focus on space. This shift moved beyond the traditional priority given to historical analysis. It presented space not as a mere backdrop, but as an active force shaped by society and essential to our understanding of the world. Chinese Literary Geography developed within this global intellectual context, which fundamentally reexamined the importance of spatial concepts.

1.1 The Hegemony of Time and the Nineteenth-Century Legacy

In the modern era, and especially during the nineteenth century, the primary focus of intellectual thought was history. As the philosopher Michel Foucault observed, history was the "great obsession." Scholars were concerned with ideas of development, evolution, and progress through time. This perspective was shaped by powerful intellectual currents like Hegel's philosophy of historical change and Darwin's theory of evolution. In this climate, time was considered the most important dimension for understanding the world. This emphasis on time deeply influenced literary studies. A key example is the work of Hippolyte Taine and his influential *History of English Literature*, published in 1863 [1]. Taine proposed that literature could be explained by three factors: race, milieu, and moment. Although "milieu" suggests a concern with environment or place, it was largely treated as a static physical setting. It was the unchanging stage for the main action, which was the historical "moment." In this view, space was seen as fixed and lifeless, while time was dynamic and generative.

This historical approach placed geography in a secondary role. It was seen as a passive backdrop or a simple limitation, not an active force that helps shape culture and literature. The prevailing "spirit of the times" held far more power than any "spirit of a place." The story of human advancement was understood almost exclusively as a journey forward through time.

1.2 The Insurrection of Space: Foucault, Lefebvre, and Soja

This focus on history began to change in the middle of the twentieth century. By the 1970s and 1980s, new postmodern theories brought space to the center of attention. The philosopher Michel Foucault famously declared that while the nineteenth century was obsessed with history, "the present epoch will perhaps be above all the epoch of space" [2]. He suggested that our contemporary world is defined less by progress through time and more by the arrangement of things in space—their connections, their networks, and their coexistence.

Foucault introduced the idea of the "heterotopia." These are real spaces that operate differently from their surroundings. They are counter-sites that reflect, challenge, or overturn the norms of everyday society. For scholars of literature, this idea became a valuable tool. It helped them see how texts can create alternative worlds that question dominant cultural stories. At the same time, Henri Lefebvre was reshaping how we understand space. In his major work, *The Production of Space*, he argued that space is not simply an empty container [3]. Instead, it is something actively created by social

activity and human relationships. He described a three-part model for understanding any space, which has become essential for literary geography.

First, there is spatial practice. This is the physical space we perceive and move through in our daily routines. Second, there are representations of space. This is space as it is conceived and mapped by experts like planners and scientists. Third, there are representational spaces. This is the space as it is directly lived and imagined through art, symbols, and personal experience. Lefebvre's model allowed literary critics to see a text not just as a picture of a place, but as an active participant in creating social meaning. A novel or poem functions as a "representational space" that shapes how we understand our world.

Building on this foundation, the geographer Edward Soja further developed this spatial thinking [4]. He criticized the overemphasis on history in social theory and argued for a renewed focus on space. His concept of "Thirdspace" became particularly influential [5]. Thirdspace is the idea that a place can be both real and imagined at the same time. It is both a physical location and a product of meaning, memory, and metaphor. For literary study, this means that a fictional place like William Faulkner's Yoknapatawpha County is not simply invented. Nor is it just a documentary copy of the real American South. It exists in a Thirdspace, where the author's geographical imagination reshapes our understanding of the material world.

1.3 The Emergence of Literary Geography in China

This new focus on space, which moved beyond seeing environment as a fixed setting to understanding it as something actively created, provided the foundation for Chinese Literary Geography to establish itself as a distinct field. The discipline draws from a deep native tradition. This includes ancient works like the Book of Songs, where poems were organized according to the region, or "Guo Feng," from which they came. However, its modern form is a deliberate project. It seeks to blend this longstanding Chinese scholarly tradition with the Western theories of space that emerged in the late twentieth century.

Leading scholars in China, such as Mei Xinlin, advocate for a "New Literary Geography" [6]. Their goal is to move past simple contrasts between Chinese and Western thought or between ancient and modern approaches. Instead, they aim to build a unified theoretical framework. This framework combines two key perspectives. The first is the "Literary Perspective," which examines the historical patterns of where authors lived and where literary works originated. The second is the "Geographical Perspective," which investigates how space is represented within the texts themselves and the spatial logic that governs those representations.

This study will examine the development of this field. It will analyze the fundamental shifts in how space and literature are understood, the new research methods that have been adopted, and the key discussions currently shaping Chinese Literary Geography as an academic discipline.

2 DEFINING THE DISCIPLINE: DIVERGENT PARADIGMS AND THE QUEST FOR INTEGRATION

The definition of Literary Geography is not fixed or uniform. It is a field shaped by debate, with different researchers holding distinct views on what constitutes knowledge and where the focus of study should lie. A close examination of the discipline shows a significant split in approach. Scholars like Dai Juncheng have framed this as a dichotomy between the Western "Geographical Perspective" and the Chinese "Literary Perspective."

2.1 The "Geographical Perspective": Western Trajectories

Literary geography in the Western academic tradition has followed a clear path of development. Scholars such as Marc Brosseau have identified several distinct phases in its evolution, each grounded in different theoretical perspectives [7,8]. These phases are often linked to broader trends within human and cultural geography.

The first phase, active before the 1960s, can be called the Phase of Regional Realism [9]. During this period, literary works were used mainly as sources of information. Influenced by geographers like Carl Sauer and his idea of the "cultural landscape" [10], researchers treated novels and poetry as archives of factual detail. They extracted descriptions of terrain, weather, and local customs to add richness to their maps and regional studies. In this view, literature was a passive reflection of a real, external world, and its artistic value was secondary to its descriptive utility.

A significant shift occurred in the 1970s with the Phase of Humanistic Geography. This approach turned away from mere description and focused on human experience. Drawing from phenomenology and thinkers like Gaston Bachelard, scholars studied the deep emotional connections people form with places [11]. Concepts like "sense of place" and "topophilia" became central. Bachelard's work, for example, examined how intimate spaces like a house hold profound personal meaning and shape memory. Literary geography in this phase became an exploration of how writing captures the feeling of belonging and the personal significance of environments.

The 1980s introduced a more politically engaged perspective in the Phase of Radical and Marxist Geography. Inspired by theorists like David Harvey, scholars began to analyze the economic and power structures that shape space [12]. Harvey's concept of "time-space compression" helped explain how literature might reflect the speeding up and shrinking of the world under modern capitalism. Here, a literary text was understood as a product of its social and material context. Researchers examined how stories reveal or challenge spatial injustices, class conflict, and unequal development across cities and regions.

Finally, from the 1990s to the present, the Phase of New Cultural Geography has dominated. This phase incorporates

insights from post-structuralism, feminism, and post-colonial studies. It places great emphasis on power, identity, and representation. Scholars like Mike Crang see literature not as a mirror but as an active participant in creating meaning [13]. A text is viewed as a network that constructs our understanding of space, rather than just describing it. This distinctly "Geographical Perspective" of the discipline asks how writing assigns meaning to landscapes and how it is used to express ideas about gender, race, and national identity.

2.2 The "Literary Perspective": Chinese Trajectories

The dominant Chinese approach, termed the "Literary Perspective," differs from the Western focus. Led by scholars like Zeng Daxing and Yang Yi, it places greater emphasis on the concrete patterns of literary activity and on the historical relationship between literature and the physical world. Zeng Daxing is a leading theorist who defines the field through three core areas of study [14].

The first is Geographical Distribution. This involves a statistical and historical analysis of where literary elements are found [15]. Researchers map the native places where authors were born, the places they traveled to, and the locations where cultural centers thrived. This creates a spatial record of literary production. The second area is Regionality [16]. This examines the distinctive characteristics of literature from different areas. It explores how specific environments, such as the water towns of Jiangnan compared to the loess plateau of the Northwest, give rise to unique literary styles, forms, and artistic schools. The third is Interaction. This investigates the two-way relationship between literature and the geographical environment [17]. Zeng suggests a "mechanism of trigger," where physical landscapes and objects stimulate a writer's awareness and emotions, which then finds expression in their creative work.

Yang Yi contributes to this paradigm by advocating for a "remapping" of Chinese literature. He argues the discipline's core purpose is to reconnect writing with the "spirit of the earth." His work analyzes large-scale cultural movements, like the historical southward shift of China's cultural center, and explores how the experience of exile has shaped the literary mindset. His research highlights the profound link between regional culture and a writer's identity [18].

Mei Xinlin builds upon these foundations with his proposal for a "New Literary Geography." He aims to organize these various approaches into a structured academic discipline. He outlines four essential pillars: Concept, Discipline, Theory, and Method. For methodology, he recommends combining distribution studies and trajectory research, which tracks writers' movements, with fixed-point research, which involves deep analysis of specific locations. His vision represents a push for greater "disciplinary self-consciousness," with the goal of establishing Literary Geography as a formal field of study with a status equal to that of Literary History.

2.3 Integration and Conflict

This clear distinction between the two approaches—one centered on textual meaning and power in space, and the other on historical patterns and environmental effects—creates a foundational tension. Yet, it also presents a significant opportunity for growth. Scholar Cao Shitu has attempted to build a connection between them [19]. He defines the discipline as the study of the dynamic relationship between literature and geography. This definition intentionally includes both the traditional Chinese idea of literature's "wind-soil" character, shaped by local environment, and the spatial principles that govern its changes across different areas.

Looking ahead, the primary challenge for Chinese Literary Geography is to achieve a synthesis. The field must find a way to combine the detailed, evidence-based methods of its "Literary Perspective" with the interpretive depth and conceptual frameworks of the Western "Geographical Perspective." The future path involves using Western spatial theory not as a replacement, but as a lens to examine and bring new understanding to the immense historical record of Chinese literature. Success in this integration will determine the discipline's maturity and its unique contribution to global scholarship.

3 THEORETICAL CORE: FROM "HUMAN ONTOLOGY" TO "GEOGRAPHICAL ONTOLOGY"

A significant theoretical evolution within Chinese Literary Geography involves a proposed change in its fundamental perspective. This evolution suggests moving from an understanding centered on the author or the literary subject to one centered on geography itself. This shift grapples with core philosophical questions about what literature essentially is and about the connection between the individual who writes and the world they inhabit.

This means that instead of asking primarily about an author's life or intentions, the focus turns toward the role of place. The key inquiry becomes how geography actively shapes literary creation, meaning, and form. This perspective suggests that the essence of a literary work is not found solely within the writer's mind, but emerges from a dynamic engagement with a specific environment, history, and cultural landscape. It reframes the relationship, seeing the writer not just as an independent creator imposing meaning onto a passive world, but as a participant within a geographical context that profoundly influences and enables their creative expression.

3.1 The Dominance of "Human Ontology"

Since the 1980s, the theoretical landscape of Chinese literature has been heavily influenced by "Human Ontology" (*Renxue Bentilun*). This trend was catalyzed by Liu Zaifu's seminal essay "On the Subjectivity of Literature" [20]. Writing in the context of the post-Cultural Revolution thaw, Liu argued for the liberation of literature from rigid

political determinism. He emphasized the centrality of human subjectivity—agency, will, creativity, and inner strength. Literature was redefined as the "poetic displacement of human internal nature," focusing on the exploration of the self and the "inner universe" of the subject.

The human-centered approach advocated by Liu was an important step forward. It corrected the earlier, simpler view that literature was only a mirror of social and political conditions. However, critics such as Yuan Xun contend that this approach eventually fostered a form of "anthropocentric arrogance." By concentrating entirely on the human individual, this perspective broke the essential connection between literature and the external, natural world. It came to see the environment only as a passive background for human action or as a screen for projecting human feelings. In doing so, it failed to account for the real and significant ways the physical world shapes and limits human experience and creativity.

3.2 The Proposition of "Geographical Ontology"

To correct this imbalance, scholars proposing a "Geographical Ontology" base their argument on the materialist philosophy of Karl Marx. Specifically, they draw from his early work, *the Economic and Philosophic Manuscripts of 1844* [21]. Scholar Yuan Xun uses this foundation to present a materialist critique of the human-centered approach. He highlights Marx's statements that a person "can only express his life by means of real, sensible objects," and that a human is "a natural, corporeal, sensible, objective being... a passive, conditioned, and limited being." This perspective places the relationship between "Man and Earth" at the center of human existence. According to this view, there are three key principles.

First is our Dependence on Nature. Human life is fundamentally reliant on the natural world. We are not pure spirits, but physical beings whose very existence is shaped by our environment. Second is the principle of Objectification. Literary creation is not simply the outpouring of an inner mind. It is the process of turning natural reality into an object, such as a poem or novel. The external world is the necessary material and starting point for any creative act. Third is the acknowledgment of human Limitations. Unlike the idea of unlimited human freedom, the geographical perspective recognizes that humans are also passive and finite. Literature arises from the interaction between human creative will and the real constraints of the environment.

Zou Jianjun has expanded this idea [22]. He argues that the fundamental "Man-Earth" relationship is the base for all other connections in literature. This includes the "Writer-Earth" relationship, which examines how geography shapes the author, and the "Text-Earth" relationship, which analyzes how a literary work represents place. In this framework, literature is redefined. It is not merely "the study of man," but rather "the study of man in the world." This restores the geographical dimension to a central position within literary theory.

4 METHODOLOGIES: CARTOGRAPHY, CRITICISM, AND IMAGINATION

The methods used by scholars in Chinese Literary Geography have grown more varied and sophisticated. This expansion is largely due to the thoughtful adoption and adaptation of theories developed in the West. Three specific methodological approaches have become especially important for analysis within the field. These are Geocriticism, the study of Imaginative Geographies, and the practice of Literary Cartography. Each provides a distinct set of tools for examining the relationship between literature and place.

4.1 Geocriticism: From Egocentrism to Geocentrism

Bertrand Westphal established the method known as "Geocriticism" [23]. His approach fundamentally shifts focus away from the author. Westphal argues that traditional literary study is too limited, concentrating either on the author's life or on the text in isolation. In contrast, he proposes "Geocentrism." This means placing the primary emphasis on the location itself, which becomes a focal point where many different depictions converge.

Westphal's method relies on two main concepts. The first is Multifocalization. Instead of examining one author's portrayal of a place, geocriticism gathers and compares many representations of the same location from various authors, time periods, and cultural perspectives. For example, it would study Paris not just through Balzac's novels, but also through the works of Zola, Proust, and later immigrant writers. This leads to the second concept, Stratigraphy. By layering these multiple representations, we see the place as an accumulation of cultural meaning over time, much like geological strata. Each literary text adds a new layer to our understanding of a city or landscape. Westphal also emphasizes Polysensoriality. This means paying attention to how literature evokes all the senses—not just sight, but also sound, smell, and touch—to build a full experience of a space, moving beyond a simple visual map. Furthermore, he highlights Transgression. Drawing on philosophical ideas about boundaries, geocriticism explores how literature crosses and blurs lines. It examines how texts can challenge fixed identities of places, redefine what is central or marginal, and reimagine the connections between different spaces.

Robert Tally Jr., a prominent scholar who explains and applies Westphal's ideas, strengthens this view [24]. He describes the writer as a kind of mapmaker, engaged in "literary cartography" [25]. For Tally, geocriticism is essentially a way to read the "spatiality" within a text, analyzing how the very structure of a story organizes, creates, and gives meaning to space.

4.2 Imaginative Geographies: Power, Knowledge, and the Other

The concept of "Imaginative Geographies," developed by Edward Said, offers a powerful method for examining how space, power, and representation are connected. Said proposed that the way we understand geography is not neutral. It is an imaginative creation that often supports specific political or ideological goals. In his influential work *Orientalism*, he showed how Western writers and scholars constructed a vision of "the East." They created a binary division, positioning their own lands as rational and civilized, while depicting Eastern societies as irrational and exotic [26]. This imaginative geography, supported by a structure of power, was used to justify colonial rule and domination. Later scholars have expanded this framework. Derek Gregory applied it to analyze what he calls the "colonial present" [27]. By studying travel narratives and colonial era literature, he demonstrates how a "geographical imagination" is used to define and script foreign places, like Egypt or Afghanistan, in ways that make military or political intervention seem necessary and legitimate [28-31].

Another scholar, Joanne Sharp, contributes to this method by examining the process of "demystification" [32]. In her critique of Roland Barthes' writings on Japan, she argues that reducing a complex culture to a collection of artistic signs is itself a form of "geographical violence" [33]. This approach, which she calls "hyper-Orientalism," strips a place of its political and social reality. Sharp instead advocates for a "remystification" that acknowledges the agency and inherent complexity of the other culture, rather than attempting to fully explain or define it.

Within Chinese literary studies, this methodology of Imaginative Geographies is actively used. It provides a lens to analyze enduring cultural divisions, such as the literary contrast between North and South China. It is also applied to study the representation of border regions like Xinjiang and Tibet in literature, and to understand the dynamics of self and other in literary encounters between China and the West.

4.3 Literary Cartography: The Digital and Quantitative Turn

Franco Moretti transformed literary studies with his ideas about "Literary Cartography" and "Distant Reading." He argued that the conventional method of closely analyzing a small selection of classic texts is not adequate for understanding literature as a vast, interconnected global system. In response, he proposed "distant reading." This approach uses large collections of data to identify broad patterns and trends across literary history. In his book *Atlas of the European Novel*, Moretti demonstrated this by creating maps to trace how the novel spread, to show where certain plot types were common, and to follow the geographic movements of characters within stories [34,35].

This methodology has inspired a wider "Digital Turn" in the twenty-first century. Researchers now employ Geographic Information Systems and other digital mapping tools to visualize literary information. These techniques allow for precise examination of patterns, such as the travel routes of authors, the concentration of literary activity in certain cities, and how the emotional tone of literature might vary from one region to another. Nevertheless, scholars like Wang Yixuan point out a significant challenge. The danger is that this quantitative, map-based abstraction can overshadow the detailed qualitative experience of an individual literary work. The key for the digital turn is to maintain a balance, ensuring that the aesthetic particularity and unique texture of literature itself are not lost in the process of creating large-scale models and visualizations.

5 THE CHINESE CONTEXT: SYNTHESIS AND THE CONFLICT OF PERSPECTIVES

The growth of Chinese Literary Geography represents an active and critical engagement with global thought, not a simple adoption of Western ideas. It is a deliberate process of combining different scholarly traditions. The project to build a "New Literary Geography" specifically seeks to merge the detailed, evidence-based methods long practiced in Chinese studies with the analytical frameworks developed in Western spatial theory. This synthesis aims to create a distinct and robust academic discipline that speaks to both local literary history and broader theoretical conversations.

5.1 The "New Literary Geography" System

Mei Xinlin provides a clear framework for this combined approach. He describes a future disciplinary structure built upon four essential components.

The first component is Concept. This involves creating a shared vocabulary that brings together Western ideas like heterotopia and thirdspace with traditional Chinese concepts such as fengtu (local character) and diqi (spirit of the earth). The second is Discipline. This pillar calls for formally establishing Literary Geography as a primary field of study, with a status equal to that of Literary History. This institutional recognition affirms that space is as vital as time for understanding literature. The third is Theory. Here, the goal is to develop original theories rooted in the Chinese context. Examples include the "Genealogy of Literary Families" and "Geographical Ontology," which aim to explain the unique patterns and forces shaping Chinese literary creation. The fourth is Method. This advocates for a blended methodology. It pairs the traditional Chinese practice of "evidential research," which focuses on verifying historical facts, with modern techniques like spatial analysis and digital cartography.

5.2 The Conflict: Literary Perspective vs. Geographical Perspective

A clear tension persists within the field, identified by scholars like Dai Juncheng, between what is termed the "Literary Perspective" and the "Geographical Perspective."

The Literary Perspective, championed by scholars such as Zeng Daxing, concentrates on the concrete patterns of

literary activity. It is primarily concerned with empirical questions: Where were authors born? Where did they travel and write? This approach, grounded in a tradition of historical materialist analysis, uses maps and statistical data to build what might be called the factual skeleton of literary history.

In contrast, the Geographical Perspective, shaped by the adaptation of Western theorists like Marc Brosseau, focuses on how space is portrayed and given meaning within literary works. It asks interpretive questions: How does a text construct its sense of place? What relationships of power are embedded in this representation? This approach is fundamentally analytical, often drawing on post-structuralist thought to critique the cultural and political dimensions of spatial description.

This divergence defines a central methodological debate, between mapping the external facts of literary production and interpreting the internal construction of space within the text itself.

5.3 The Textual Path as Synthesis

In response to this conflict, Zou Jianjun proposes a mediating "Textual Path." He cautions against two potential pitfalls. The first is allowing the field to become purely sociological, where literature is reduced to mere data points. The second is allowing it to become purely geographical, where a literary work is treated only as a documentary record of a place. Zou's "Textual Path" asserts that the literary text itself must remain the central focus of study.

He builds upon Michel Collot's observation about geocriticism. Zou argues that while a place-centered approach is valuable, it should not come at the cost of ignoring the author's individual perspective or the unique aesthetic qualities of the work. The essential task for Literary Geography, in his view, is to examine precisely how a text transforms real-world geography into a distinct "literary space." This requires close attention to the tools of writing, such as narrative form, metaphor, and imagery, as well as to the reader's own lived experience of the world the text creates [36].

6 CONCLUSION: THE FUTURE OF THE DISCIPLINE

The trajectory of Chinese Literary Geography demonstrates a remarkable evolution from a marginal subfield to a robust, self-conscious discipline. By navigating the shift from the nineteenth-century hegemony of time to the postmodern "Spatial Turn," Chinese scholars have opened new horizons for literary inquiry.

The future of the discipline lies in the deepening of this synthesis.

First, the theoretical core of "Geographical Ontology" offers a profound philosophical basis for the discipline, grounding literary study in the material reality of the "Man-Earth" relationship. This resonates with the global turn towards the Environmental Humanities and Ecocriticism.

Second, the methodological integration of Geocriticism, Imaginative Geographies, and Literary Cartography provides a sophisticated toolkit for analyzing the complex interplay of space, power, and representation.

Third, the Digital Humanities offer unprecedented opportunities to bridge the "Literary Perspective" and the "Geographical Perspective." GIS technologies allow for the visualization of vast datasets regarding writer distribution (the Literary Perspective), while also enabling new forms of "distant reading" that reveal the spatial structures of narrative (the Geographical Perspective).

Ultimately, Chinese Literary Geography is moving towards a unified dialectic where space is understood as both a material reality and a textual construction, and where the map and the territory are read together in a "Thirdspace" of critical inquiry.

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BRIDGING THE DIGITAL-CULTURAL DIVIDE: DIGITAL LITERACY AND COMMUNICATIVE EMPOWERMENT OF ICH INHERITORS IN CHINA

YiWu Zhou
Zhejiang Gongshang University Hangzhou College of Commerce, Hangzhou 311500, Zhejiang, China.

Abstract: This study investigates the digital literacy crisis facing Intangible Cultural Heritage (ICH) inheritors in China, a group pivotal for cultural sustainability yet increasingly marginalized in the digital public sphere. Focusing on marriage custom inheritors in Zhejiang Province, we develop and validate a "Culture-Communication" oriented tripartite model of digital literacy—comprising survival, production, and communication competencies. Employing a mixed-methods approach (N=317 survey; n=15 interviews), the research reveals severe structural imbalances in digital competencies, marked by a critical deficit in content production skills. Significant geographic and generational "mirror fractures" are identified, where technical proficiency and cultural authority are inversely distributed across age groups. A Structural Equation Model confirms digital production competency as the primary driver of perceived communication efficacy (Total β=0.78). The findings diagnose a triple rupture chain—subjective, technical, and institutional—constraining effective digital dissemination. In response, the study proposes an integrated "Three-Path Synergy & Five-Dimensional Empowerment" framework. This model advocates for systemic interventions at individual, organizational, and policy levels to enhance literacy, coupled with strategic empowerment in content, IP, platforms, community, and ecosystem development. The framework aims to facilitate inheritors' subjectivity reconstruction from passive cultural holders to proactive digital communicators, offering a actionable pathway for ICH's adaptive evolution within national cultural digitalization strategies.
Keywords: Intangible cultural heritage; Digital literacy; Cultural communication; Digital divide; Mediatization; China; Zhejiang

1 INTRODUCTION

The integration of China's national cultural digitalization strategy with intangible cultural heritage (ICH) protection mandates a critical paradigm shift: from on-site, embodied transmission to digital dissemination. This transition places ICH inheritors—the core human repository of living traditions—at a complex crossroads. While digital platforms offer unprecedented reach, they also risk rendering inheritors, particularly an aging cohort, as "culturally mute" in the new media landscape [1-2]. A paradoxical "subjectivity crisis" emerges: elder inheritors face significant digital access and usage barriers, while some younger, tech-savvy practitioners may prioritize technical form over cultural substance, leading to the erosion of authentic meaning. Consequently, ICH is often passively "displayed" rather than actively communicated by its rightful bearers.

Zhejiang Province, a nexus of advanced digital economies and rich ICH resources, presents a salient context. Its visually expressive marriage customs (e.g., Ninghai's "Ten-Mile Red Dowry") are potent candidates for digital storytelling. Yet, preliminary data shows over 68% of relevant inheritors are above 60, with digital competence strongly negatively correlated with age. This tension between technological environment and inheritor capacity frames our core research problem: How can ICH inheritors reconstruct their subjectivity as empowered digital communicators?

This study seeks to address four specific questions:

RQ1: How can a culturally-sensitive, communication-oriented model assess the digital literacy of ICH inheritors?

RQ2: What is the current state and structural characteristics of their digital literacy?

RQ3: How does this literacy impact ICH communication efficacy?

RQ4: What empowerment strategies can enhance their digital agency?

2 LITERATURE REVIEW & THEORETICAL FRAMEWORK

2.1 Digital Literacy in the ICH Context

Digital literacy has evolved from basic technical skills to encompass critical consumption and creative production within digital societies. Foundational frameworks like the EU's DigComp provide a universal baseline [3]. However, for ICH inheritors, digital practice is inherently domain-specific. Their literacy is not about general office software proficiency but about leveraging 3D scanning for artifact preservation, crafting narrative videos for ritual explanation, and utilizing platform algorithms for cultural outreach. Thus, we conceptualize ICH inheritors' digital literacy as a specialized form of literacy for cultural communication [4-5].

2.2 Theoretical Anchors

- Uses and Gratifications (U&G): This theory positions inheritors as active users seeking to fulfill needs like cultural documentation, skill transmission, and value affirmation through media[6]. Digital literacy determines their capacity to utilize tools effectively to meet these needs.
- Digital Divide: The divide extends beyond basic access to encompass a "second-level" gap in usage skills and a "third-level" gap in outcome benefits. In ICH, this manifests as intergenerational fractures in both digital competency and the authority of cultural interpretation[7].
- Mediatization: Digital media are not neutral channels but active agents that reshape social and cultural practices[1-2]. The process of ICH transmission itself is becoming mediatized, making inheritors' ability to navigate and steer this process crucial.

2.3 A Tripartite "Culture-Communication" Model

Synthesizing these lenses[3-4, 6-7], we propose a three-dimensional model (Figure 1):
- Dimension 1: Digital Survival Competency (The Access Layer). Foundational skills for operating devices and retrieving online ICH information.
- Dimension 2: Digital Production Competency (The Core Layer). The capacity for creative digital content creation, including recording, modeling, and narrating ICH elements.
- Dimension 3: Digital Communication Competency (The Diffusion Layer). Strategic skills for content distribution, community engagement, and value realization on digital platforms.

This model prioritizes the integration of technical skill with cultural intentionality and communicative strategy, centering the inheritor's agency.

3 METHODOLOGY

A convergent parallel mixed-methods design was employed.
Quantitative Strand: A survey was administered to 317 marriage custom ICH inheritors across Zhejiang, sampled via stratified and snowball methods. The instrument included a 62-item Digital Literacy Scale (α=0.89), a Perceived Communication Efficacy Scale, and demographic questions. Data analysis utilized SPSS 26.0 for descriptive/inferential stats and AMOS 26.0 for Structural Equation Modeling (SEM).
Qualitative Strand: 15 semi-structured interviews were conducted with inheritors selected for maximum variation in age, location, and ICH type. Transcripts were analyzed thematically to provide depth and context to statistical patterns.

4 FINDINGS

4.1 Structural Imbalance in Digital Literacy

Survey data revealed a moderate overall level but severe inter-dimensional imbalance (Table 1).

Table 1 Digital Literacy Scores (N=317, Max=100)

Competency Dimension	Mean (M)	SD	Assessment
Digital Survival Competency	48.2	12.5	Medium-Low
Digital Production Competency	29.7	10.8	Critically Weak
Digital Communication Competency	35.4	11.6	Low-Medium

Only 13% reported basic 3D modeling skills, and under 10% could independently produce coherent ICH short videos, indicating a widespread failure to transition from digital consumers to cultural producers.

4.2 Pronounced Geographic and Generational Divides

A "core-periphery" gradient was evident, with scores in Hangzhou/Ningbo significantly higher than in mountainous regions. GWR analysis identified digital infrastructure density (β=0.63, $p<0.01$) as the strongest spatial predictor.
More critically, a "mirrored fracture" was observed between generations (Table 2). While inheritors under 35 significantly outperformed those over 60 in digital operational skills, the reverse was true for deep cultural knowledge.

Table 2 Intergenerational "Mirrored Fracture" (Sample Indicators)

Indicator	<35 Group	>60 Group	t-value	p-value
Device Operation Proficiency	82.5 ± 6.3	35.7 ± 8.9	8.72	<.01
Mastery of Ritual Procedures	34.7 ± 7.2	81.5 ± 9.3	-7.31	<.01

Indicator	<35 Group	>60 Group	t-value	p-value
Interview data illuminated this divide: an elder inheritor expressed anxiety about "pressing the wrong button," while a younger inheritor acknowledged misusing a traditional symbol in a digital design due to shallow cultural understanding.				

4.3 Digital Literacy as a Driver of Communication Efficacy

The SEM model demonstrated excellent fit (χ^2/df=1.89, RMSEA=0.06, CFI=0.95). Digital literacy had a strong total effect on perceived communication efficacy (path coefficient=0.78, p<.001). Crucially, Digital Production Competency was the strongest direct driver (β=0.45), followed by Communication (β=0.28) and Survival (β=0.22) competencies. This confirms that content creation ability is central to effective digital communication.

4.4 The Triple Rupture Chain

Analysis identified three interlinked structural barriers:

- Subjective Rupture: Internal fragmentation among inheritors based on age and tech acceptance.
- Technical Rupture: A mismatch between generic digital tools and the nuanced, embodied, symbolic nature of ICH expression.
- Institutional Rupture: Disjointed policies offering superficial, non-systematic digital training with few tangible incentives for digital practice.

5 DISCUSSION: AN INTEGRATED EMPOWERMENT FRAMEWORK

To address the systemic ruptures, we propose an integrated "Three-Path Synergy & Five-Dimensional Empowerment" model (Figure 2).

5.1 The "Three-Path Synergy" for Literacy Enhancement

- Individual Path: "Silver-Youth" Digital Pairing. Formalized mentoring that pairs elder inheritors (cultural depth) with youth (digital skills) for bidirectional learning, supported by a "digital inheritance credit" system.
- Organizational Path: Tiered Digital Workshop Network. Establishing provincial-to-county workshops offering graduated access to technology and tailored, progressive training modules.
- Institutional Path: Digital Literacy Credit Bank. Institutionalizing digital competency by integrating it into the official inheritor assessment and funding system via a lifelong learning credit mechanism.

5.2. The "Five-Dimensional Empowerment" for Communication

Literacy must be channeled into effective practice through:

- Content Production: Building structured, metadata-rich "digital cultural gene banks" to provide accurate, remixable foundational assets.
- IP&Narrative: Developing unified regional cultural IPs (e.g., "Zhejiang Weddings") for coordinated transmedia storytelling.
- Platform&Scenario: Creating immersive, blended physical-digital experiences (e.g., AR heritage trails, MR museum installations).
- Community&Interaction: Fostering co-creative online communities to transform audiences from viewers to participants.
- Ecosystem Synergy: Forming cross-sector alliances (government, tech, media, academia) to pool resources and incubate innovative projects.

This integrated model aims to create a virtuous cycle where enhanced literacy enables effective communication, the rewards of which further motivate learning and innovation.

6 CONCLUSION

This study establishes that the digital literacy of ICH inheritors is a specialized, multidimensional construct critical for their communicative agency[4-5, 8-9]. The empirical diagnosis reveals not just a deficit but a structural crisis characterized by a critical lack of production skills and a reinforcing "mirrored fracture" between generations. The proven strong link between production competency and communication efficacy underscores the urgency of moving beyond basic digital access to fostering sophisticated content creation capabilities.

The proposed framework offers a holistic policy and intervention roadmap. It shifts the focus from perceiving inheritors as passive beneficiaries of digitization to actively empowering them as central authors and architects of their cultural heritage's digital future. This subjectivity reconstruction is essential for ensuring that ICH remains a dynamic, meaningful, and participant-driven force within the evolving digital society of China and beyond.

7 LIMITATIONS & FUTURE RESEARCH

Limitations include the regional scope and cross-sectional design. Future research should track literacy evolution longitudinally, integrate objective platform metrics, and explore the implications of generative AI on cultural production. Comparative international studies could further contextualize these findings within global debates on cultural rights and digital equity[10].

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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