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# TRENDS IN SOCIAL SCIENCES AND HUMANITIES RESEARCH



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# Trends in Social Sciences and Humanities Research

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## APPROACH TO LEARNING BEHAVIOUR ANALYSIS FOR HIGHER-ORDER THINKING DEVELOPMENT: EDUCATIONAL BIG DATA PERSPECTIVE

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**Abstract:** With the rapid development of information technology, educational big data gradually become an important resource in the field of education. Characteristic by large data volume, diverse types and low value density, educational big data can provide rich information support for education and teaching. Higher-order thinking, as a necessary quality of innovative talents, has been increasingly valued in the field of education. Educational big data is closely linked to the development of higher-order thinking, and through the analysis of educational big data, it can provide an in-depth understanding of students' learning behaviors and provide a basis for the cultivation of students' higher-order thinking. The purpose of this paper is to explore the mechanism of promoting the development of students' higher-order thinking through the analysis of students' learning behaviors in the perspective of education big data. After training, the machine automatically annotated text used in the examples of this paper achieves a score of 4.5 or more, with an accuracy rate close to 0.98, which can meet the needs of classroom applications. It can be seen that when this paper is applied to actual classroom evaluation, it lays an important foundation for carrying out large-scale comparative research on classroom teaching as well as digging into the laws of classroom dialogue, and it can break down the barriers of mathematics teaching between districts and schools, break down the effect of data silos, and provide a relatively uniform basis for the comparison and evaluation of the level of classroom teaching.

Keywords: Big data in education; Higher order thinking; Learning behaviour analysis

#### **1 INTRODUCTION**

At present, research on educational big data and higher-order thinking at home and abroad has achieved certain results. In terms of educational big data, research mainly focuses on data collection, processing and analysis, aiming to explore the potential value in educational data and provide support for educational decision-making. In terms of higher-order thinking, the research mainly focuses on the connotation, cultivation method and evaluation system of higher-order thinking, aiming to improve students' innovation and problem-solving ability. However, there are relatively few studies that combine educational big data with the development of higher-order thinking, and further in-depth exploration is needed.

Along with the rise of online learning platforms, prediction studies based on students' online learning behaviors have become increasingly common, involving relevant techniques from several fields, including traditional learning behaviour analysis based on human observation and learning behaviour analysis based on machine learning algorithms. Based on traditional methods, it often starts with academic performance.Hasan et al. collected course data from 22 students and used GPA, sequence course grades, and online module quiz data to predict the final grade level[1]. Burgos et al. collected course data from more than 100 students and used the grades of quizzes, assignments, and other modules in the Module platform to predict whether students could pass the the course[2]. Amrieh et al. predicted students' performance by analyzing data from an online learning platform and obtaining the number of times students spoke in discussions in forums, the number of times they accessed resources, and the amount of time they spent reading the material, which comprised a vector of students' online learning behavioral features, and found that there was a strong correlation between online learning behaviors and students' performance[3]. Cobb et al. predicted the performance of students by observing fourth graders over a 9-day classroom observations of fourth graders, counting the proportion of different student behaviors in the classroom to predict students' reading and spelling scores[4]. McKinney et al. conducted 5-minute classroom observations of children participating in a language arts program every 4 days, predicting performance based on 120 observations of children's behaviors[5]. Allen et al. used classroom observation to analyse teacher-student interaction behaviors in the classroom, finding a strong correlation between online learning behaviors and student performance[6]. The manual observation method has become a bottleneck in the research of teaching behaviour due to its low coding efficiency and high labour cost. With the rapid development of machine learning technology, researchers have begun to try to adopt deep learning methods to obtain students' classroom behaviors. Using classroom videos, Bidwell et al. measured student engagement by using a Hidden Markov Model to analyse students' gaze targets in the classroom[7]. Thomas et al. calculated students' attention levels by using OpenFace open-source software to analyse students' facial expressions, head postures, and eye gaze targets in the classroom[8]. Ashwin et al. proposed a hybrid convolutional neural network model to analyse students' facial

expressions, gestures and body postures to reflect the learning status of students in the classroom, and found that student engagement was positively correlated with paper grades[9]. Gong et al. devised an end-to-end graphical constitutional neural network method, ACKRec, for knowledge concept recommendation in MOOC platforms, which combines students, knowledge points, and other types of of entities, such as courses, videos, and instructors, into a heterogeneous information network that guides the propagation of student preferences based on meta-paths[10]. Subsequent research has found that knowledge graphs can effectively fuse massive heterogeneous data and expert knowledge, and incorporating knowledge graphs into learner personalized recommendation models can help characterize the underlying relationships between entities and increase the interoperability of learning resource recommendations using pathway reverse inference[11]. Deep learning methods can be further classified into two categories according to the spatial-temporal relationship of the model, one category is based on the answer time sequence based on recurrent neural network RNN, which is too sketchy to model the structural information of skills[12]. The other category is based on the structure of skills based on graph neural network GNN[13], the knowledge tracking model based on graph neural network can better express the knowledge, the structure between questions and extend the model by using the edge information, so the knowledge tracking based on graphs has a broader research prospect[14-16].

In online education environments that emphasize self-directed learning, learners' self-regulated learning behaviors and self-determined learning motives have a direct impact on learning outcomes. However, this new type of teaching environment still lacks accurate teaching evaluation and learning behaviour prediction methods and tools, which greatly limits its advantages and restricts its popularity in the education field. Existing research either follows a theory-driven psychometric paradigm or favors data-driven mining of learning behaviour patterns. If these two paths are integrated, it can promote theoretical research related to online learning, examine feasible ways to improve students' online learning effectiveness, and combine them with technological means for personalized intervention. Secondly, traditional online teaching analysis research is often based on annotated data for static descriptive statistics, the output of various types of language or behaviour whether and how often they appear, the static analysis method can not respond to the teacher and student how to build a chain of thinking progression through dialogue, what is the evolutionary pattern of higher-order thinking development and other issues, it is also difficult to provide targeted process guidance for teachers to improve teaching methods. At the same time, the existing research work to build online learning learning community appeared unfair, can not guarantee the knowledge complementary between learners and other problems.

In view of the deficiencies of the existing online teaching behaviour analysis research, this paper is based on the self-developed online course teaching platform, through data collection, data extraction and analysis and mining, constructing educational big data knowledge graph, focusing on the design of model algorithms based on accurate teaching assessment and learning behaviour analysis and prediction and other applied research practices. The relevant research results are expected to provide referable templates for digital online teaching diagnostic platforms, open up new ideas and approaches for learning analytic technology to better serve online learning as well as thinking development, help improve the quality of online teaching interactions, enhance students participation and reflection ability, promote the development of students higher-order thinking, and provide targeted strategies for improving teaching and learning.

#### 2 RESEARCH PROGRAMME DESIGN

Compared with the traditional classroom education environment, online teaching, which has an online education platform with large-scale learners, faces problems such as high dropout rate and low course completion rate, and learning community can be a good solution to the above problems[17]. This paper carries out research on learning community from the perspective of group learning, and will provide a comprehensive overview of the research on learning community in online education environment, and finally construct a learning community for online teaching. The specific construction process is shown in Figure 1.



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Figure 1 Schematic Diagram of the Process of Building a Learning Community in an Online Education Environment

In this paper, we propose a hybrid neural network-based automatic annotation method for online teaching, combining the advantages of CNN in being able to extract local information such as words and phrases in the discourse and Bi-LSTM in being able to understand the global feature information in the sequence data in combination with the contextual content, to learn the annotated data and perform model training. The specific architecture is shown in Figure 2. Explore the use of intelligent recording and broadcasting equipment to collect data on the online teaching process, and transcribe the online teaching discourse information captured by audio and video into text form to establish an online teaching corpus. A linguistic representation model (BERT) is constructed to preprocess the text by representing the online teaching discourse text as continuous vectors and applying it to the downstream computational task of neural networks to prepare for automatic annotation. The linguistic representation model within the embedding layer is constructed to convert the text information into continuous vectors, and a constitutional neural network layer is used to extract local features from the continuous vectors, and encode and annotate the text information based on the local features and global features.



Figure 2 Automatic Annotation Method for Online Teaching Based on Video Text

The core of online learning facilitation mechanism is to design a friendly recommendation model for educational resources[18-19]. This project proposes to propose a group recommendation model based on a hierarchical attention mechanism, where planning consists of a two-part attention network, where the first part learns the preference weights of each member in the group decision-making process; and the second part learns the interactions between the members in the group in order to dynamically adjust the influence weights of the members, so as to merge the preferences of the different members in the group decision-making process in order to achieve the recommendation of appropriate resources to the group. The specific architecture is shown in Figure 3.

The first layer is the embedding layer. The purpose of the embedding layer is to transform high-dimensional sparse vectors into low-dimensional dense vectors to improve the computational efficiency, in which the learner and learning resource one-hot coding are converted into low-dimensional dense vectors, and the embedding vectors of the learner and learning resource are denoted as c and v, respectively.

The second layer is the aggregation layer. This layer is to aggregate the preferences of learners in the learning community to obtain the preference representations of different learning communities. The purpose of the aggregation layer is to obtain the preference representation of the learning community, which is composed of two parts: the fused representation of the learner's preferences and the subject preferences of the learning community. The preference fusion of learners in the learning community firstly utilises the hierarchical attention mechanism to obtain the corresponding embedded representation of learners based on different learning resources, and on the basis of which the embedded fusion representation of learners is obtained. The weight of the influence of different historical interactions on the learning community topic preference representation is learnt through the attention mechanism and the embedded representation of preferences is obtained.

The third layer is the pooling layer. This layer is used to capture the linear relationship between learning communities and learning resources. In it, a tracking investigation and longitudinal mediation analysis of the relationship between strategy metacognitive knowledge, learning motivation, and maths performance is conducted, focusing on the long-term effects of autonomous motivation on positive strategy metacognitive knowledge (cognitive/metacognitive strategies, competence enhancement strategies), and control motivation on negative strategy metacognitive knowledge.

The fourth layer is the full connectivity layer. This layer is used to capture nonlinear higher-order relationships between learning communities and learning resources.

The fifth layer is the prediction layer. This layer is used to compute the learning community's predicted preference scores for candidate learning resources, the final output of the model.



Figure 3 Group Recommendation Model Based on Hierarchical Attention Mechanism

#### **3 EXPERIMENTAL PROCEDURE AND DATA ANALYSIS**

Based on MOOCs, an online course teaching platform, and large-scale online education data, this project empowers interactive online teaching analysis and higher-order thinking development, focusing on models and methods of teaching evaluation, student behaviour analysis, knowledge tracking, and personalized recommendation of teaching resources, etc. The main research contents include: online teaching evaluation system oriented to the cultivation of thinking; analysis of online learning behaviors based on the theory of self regulation; study of online learning facilitation mechanism and learning community based on knowledge tracking and resource recommendation, etc. The main research includes: online teaching evaluation system for the cultivation of thinking; online learning behaviour analysis based on self-regulation theory; online learning facilitation mechanism and learning community research based on knowledge tracking and resource recommendation. The framework of the specific experimental steps is shown in Figure 4.

Firstly, to address the lack of online teaching evaluation system, biometric method is used to extract the indicators with high usage rate in the literature of online teaching evaluation, and construct the evaluation system of offline teaching oriented to higher-order thinking. Research on automatic annotation technology for online teaching based on video text, and automatic annotation and effective extraction of key features related to the cultivation of thinking in online teaching based on the evaluation system. Carry out research on the definition and classification system of elements of classroom teaching activities.

Secondly, to address the problem of low accuracy in the analysis of online teaching behaviors, we collect log data from the intelligent tutoring system, adopt the research paradigm of educational data mining, model sequential learning behaviors using the two-layer Hidden Markov Model (TL-HMM), and carry out the exploration of sequential pattern mining and the law of thought progression. Explore the construction of a relational network diagram of student-teacher relationship and student behaviour in online course platforms. Combine the self-regulated learning process with the comparison of captured learning behaviour patterns in order to describe effective learning behaviour patterns and try to make academic predictions from learning behaviour models.



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#### Figure 4 Experimental Framework

Thirdly, to address the problem of learners records, learning preferences and other behavioral characteristics in the online learning process, and then design learning community strategies or algorithms. Modelling is oriented towards entities such as learners, courses, videos and knowledge concepts and their relationships in the online education process, and structural constraints and balancing constraints are defined separately for the information of learners' knowledge structures and protective attributes (e.g. gender, profession, habits, etc.). Exploring the construction of learning communities.

Finally, to address the problems of 'resource overload and information disorientation' that exist in the recommendation of online teaching resources, we carry out research on knowledge tracking technology in the field of intelligent education and explore the construction of a knowledge tracking framework based on the learning memory process. Relying on the educational resources (texts, videos, courses) and the concepts they contain in the online education platform as a resource-concept map, we construct a learning model of the prerequisite relationship between the knowledge concepts of massive online educational resources. Construct a group resource recommendation model for online education learners based on the learning behaviour analysis of large-scale online learners.

Based on the Matlab R2021a platform for data testing, the database is selected as the WOS database, the specific experimental results are shown in Figure 5. Pre-operation using OpenCV and other algorithms to process video images, will be through the establishment of a learning rate optimization based on the structure of the deep learning framework for expression feature recognition, combined with the Tensenflow platform for training models, the use of Pandas and other deep learning algorithms to analyse and process the data and visual display, and ultimately, can improve the multimodal education collaborative database, for the analysis of the learner's s emotional state.



Figure 5 Experimental Results

As can be seen from the figure, the CNN+BiLSTM used has the highest parameters and the best training effect. After training, the score of the machine automatically annotating the text used in this embodiment reaches more than 4.5, and the accuracy rate is close to 0.98. This indicates that the machine annotation has high reliability and validity, and the machine automatically annotates each lesson, which greatly improves the analysis and annotation speed and accuracy, and reaches the level of large-scale application and analysis of classroom dialogues.

#### 4 CONCLUSION

At present, teacher training and teaching and research activities are often based on the subjective experience of expert teachers or researchers, which is random and dispersed. This project will provide scientific and prospective guidance and support for teaching and research activities and training activities, which will help to promote the transformation of online teaching and learning, develop interactive, inspirational and inquiry-based teaching and learning, and contribute to the cultivation of innovative and practicing talents, and to enhance the effectiveness of mathematics teacher training, teaching and research activities. This paper develops a sequence pattern mining technique adapted to the online teaching field, which reveals the processional developmental patterns and thinking progression laws of online teaching and learning, and learners' assistants in order to complete the learning tasks. In this paper, we propose an automatic annotation method based on CNN-BiLSTM hybrid neural network model, which is well adapted to the online teaching and learning field, and is expected to be able to accurately categorize and encode online teaching and learning discourses. Secondly, it is able to quickly process multi-type and multi-level online teaching process data, which

provides a guarantee for scaled online teaching analysis. Finally, the model relies on evaluation indicators to effectively identify and refine the thinking features such as analysis and interpretation, summation, transfer and innovation, etc., which are reflected in online teaching, and is expected to be able to dig out the hidden semantic information in the dialogue text and reflect the thinking features in the online teaching process. The results of this paper can be applied to the evaluation of online teaching quality, laying an important foundation for large-scale comparative research on online teaching as well as mining online plus some dialogue laws, breaking down the barriers of mathematics teaching between different regions and schools, eliminating the effect of data silos, and providing a relatively uniform basis for the comparison and evaluation of the level of online teaching.

#### **COMPETING INTERESTS**

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

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## THE BIRTH OF A NATION: PROPAGANDA'S ROLE IN SHAPING RACIAL VIOLENCE AND HISTORICAL NARRATIVES

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**Abstract:** This paper explores the influence of *The Birth of a Nation* (1915), one of the most controversial films in American history, which has been both condemned for its overtly racist depictions and praised for its technical innovations. The research focuses on specific scenes that portray African Americans as lustful and uncivilized predators, analyzing the film's role as propaganda that reinforced racial stereotypes and bolstered white supremacist ideologies.

Using historical analysis and primary sources, the paper examines the cultural and societal impacts of the film, particularly its role in sparking widespread racial violence, police brutality, and the resurgence of the Ku Klux Klan. By depicting African Americans as threats and glorifying the Reconstruction-era KKK, the film amplified racial tensions and legitimized violence against Black communities. The analysis highlights how the film's release contributed to the rise of the Second KKK, illustrating the connection between cinematic depictions and real-world socio-political movements. The findings underscore the film's enduring legacy as a tool of systemic racism and a catalyst for both organized white supremacy and early Black protest movements. This research contributes to the discourse on how media shapes public perception and perpetuates historical injustices, emphasizing the importance of critically examining cultural artifacts within their broader historical contexts.

Keywords: The Birth of a Nation; Racism; Propaganda; Ku Klux Klan; Racial violence; Black protest movements

#### **1 INTRODUCTION**

When people are inquired about films that have a significant effect on the political history, many will nominate *The Birth of a Nation*. It is considered one of the most controversial movies in American history. Some profess that the film should be banned due to its absurd portrayal of African Americans, always depicting them as unintelligent and sexually aggressive towards white women. However, during the premier of this movie, it was touted as a general history of the racial problem in the South and "it is like writing history with lightning." Putting this film as eventful and helpful. Among all of the disputes, denounces, and praises of this film, I believe that *the Birth of a Nation* as a propaganda, casts a negative influence on American history.

#### 2 SCENE ANALYSE

The Birth of a Nation intensified racial hate and white supremacist throw presenting African-Americans as lustful and uncivilized predators.

In a particularly infamous scene, Gus, a freedman, pursues Flora Cameron through a forest while professing his desire for marriage. In an effort to escape, Flora tragically leaps to her death from a cliff. The sequence is charged with dramatic intensity, as Flora is depicted fleeing in terror, her facial expressions conveying profound fear, with tears streaming down her face. Gus, in contrast, is portrayed as a savage figure, his eyes emphasized starkly against the darkened tone of his skin. Notably, the character of Gus, like all other Black characters in the film, was played by a white actor in blackface. The producer justified this casting choice as being essential for the "perfection" of the film [1], though it also reflects the unwillingness of Black actors to participate in such blatantly racist depictions.

In another scene, Black legislators are shown eating fried chicken and propping their bare feet up on desks. Simultaneously, the film glorified the Reconstruction-era KKK. Klan members are portrayed as fearless saviors fighting an unjust government and are described – in an intertitle quoting Woodrow Wilson – as "a veritable empire of the South" roused by "a mere instinct of self-preservation." The climax of the film occurs when Benjamin Cameron leads a group of Klansmen to rescue Elsie Stoneman from her kidnapper, a mixed-race man named Silas Lynch. In *The Birth of a Nation*, Blacks were portrayed with all of the dirtiest and rude words while the Whites were being lifted up towards the sky, praising them of being virtuous and justice.

# **3** THE BIRTH OF A NATION AS PROPOGANDA, CASTING NEGATIVE EFFECTS ON POLITICS AND RACIAL RELATIONSHIPS

*The Birth of a Nation* casted a great effect in the rise of racist activities and police brutality, also causing the rebirth of the second Ku Klux Klan. To be more specific, the movie's release marked the beginning of a period of widespread racial violence and unrest across the nation, including a spate of lynching and race riots.

#### **3.1 Evoking Police Brutality and Black Protest**

Firstly, Police brutality and black protest arises due to the racist content of *The Birth of a Nation*. The fight against *The Birth of a Nation* had transformed into the first mass black protest movement of the twentieth century. In cities such as Philadelphia and Boston, the local campaigns came to emphasize police brutality and the role of law enforcement in the protection of private property. White supremacist defended the film. For example, during the premier of *The Birth of a Nation*, many Black people including Puller decided to protest against the movie. In the chaos, Puller recalled Sergeant King shouting, "lock that nigger up." Two officers grabbed Puller by the throat, and another, by the back of the neck. Puller gasped for air. The officers dragged him for at least fifteen city blocks as he faded in and out of consciousness. Back at the theater, the chaos continued as plainclothes officer Dennis Harrington punched William Monroe Trotter in the jaw. Some even recalled: "The officers that had me by the throat were choking me couldn't remember anything," Reverend Aaron Puller shortly after his arrest on April 17, 1915 [2].

For Black activists, *The Birth of a Nation* represented more than offensive imagery; it symbolized a growing system of racial oppression, enforced by segregated venues, police intervention, and white supremacist promotion. Contemporary reflections on the film recognize it as a profound yet troubling emblem of America's racist history, serving as a reminder of the systemic discrimination that society has worked to overcome.

#### 3.2 Reviving and Inspiring the Ku Klux Klan

Secondly, *The Birth of a Nation* played a pivotal role in the revival of the Ku Klux Klan (KKK), which had disbanded in the late 19th century. At the time of the film's release, the original Reconstruction-era Klan, formed by former Confederate soldiers to target Black political leaders and their white allies, no longer existed. This earlier iteration including at most half a million members [3], operating primarily in the South, dissolved following the passage of the Enforcement Act of 1871, which outlawed many of its violent tactics. However, six months after the film's premiere, William J. Simmons reignited the Klan's existence by burning a cross atop Stone Mountain, Georgia. Influenced by the lynching of Leo Frank and media coverage of the film, Simmons declared himself the "Imperial Wizard" of the newly-formed Second Klan on Thanksgiving Day 1915 [4], branding it as "a high-class order for men of intelligence and character."

Although the Klan's membership grew slowly during the film's roadshow, the establishment of the Klan's Propagation Department in 1920 catalyzed its rapid expansion [5]. By 1924, the Second KKK had established chapters in every state and amassed over four million members, representing nearly 10% of the nation's white male adult population. While historians have often attributed the film's glorification of the Klan and its racist depictions of African Americans to the resurgence of the KKK and heightened racial tensions [6], direct empirical evidence for these claims remains limited [7]. Nonetheless, counties that screened the film were over 60% more likely to establish a chapter of the Second KKK, underscoring its significant influence.

In addition to spurring the creation of the Second KKK, *The Birth of a Nation* inspired many of its most infamous practices. After Flora Cameron's suicide, the film shows Klan members burning a cross drenched in her blood before lynching her pursuer. By all historical accounts, the Reconstruction-era KKK never burned crosses. The first recorded instance of cross-burning in the United States was at the founding of the Second KKK. While Simmons described the act as symbolic of "a service of love and sacrifice to our age and generation," it had no actual history in the Klan and was in fact drawn from the Scottish traditions of The Clansman's author, Thomas Dixon Jr [8].

#### 4 CONCLUSION

In conclusion, *The Birth of the Nation*, as propaganda has casted a negative effect on American history. It not only sprinkled the rise of racism, causing more Black people to be discriminated and treated with rudeness and disrespect. It caused the large scale of Black protest and police brutality. With hundreds and thousands of Black people enduring violence behaviors from White police and racist language at the same time. Lastly, it triggered the rebirth of the second Ku Klux Klan by beautifying them in the movie, portraying them as organizations pursuing justice, and cleaning the threats -in their minds Black people-for America. Therefore, *the Birth of a Nation* casted a negative effect on American history.

#### **COMPETING INTERESTS**

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

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## INTEGRATING FILM ANALYSIS AND CASE STUDIES: PEDAGOGICAL INNOVATIONS IN SOCIOLOGY EDUCATION

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**Abstract:** Traditional theoretical instruction in sociology courses often struggles with the challenges of abstraction and disconnect from practical application. This study explores an innovative teaching approach that combines film analysis with case study methodology, aiming to link abstract sociological concepts with real-world social contexts. Through techniques such as situational introduction, case analysis, and classroom discussion, students gain a concrete understanding of sociological theories within tangible social phenomena, enhancing emotional resonance, critical thinking, and social observational skills. This approach bridges theory and practice, fostering students' analytical capabilities in sociology and their preparedness for practical applications.

Keywords: Sociology teaching innovation; Film analysis; Case study method; Pedagogical reform; Elderly care management

#### **1 INTRODUCTION**

In undergraduate education for elderly care management, sociology serves as a foundational course, essential for helping students understand social structures and phenomena. However, the course faces unique challenges within this discipline. First, sociology is taught as a foundational course in older adults care management program, which falls under the umbrella of public management. Its core disciplines include public management, sociology, and medicine. Given the limited curriculum space, sociology is often restricted to a single foundational course. As a result, this course must establish a comprehensive framework for students to grasp fundamental sociological knowledge and concepts.

Second, compared to sociology majors, elderly care management students often face greater difficulty in understanding sociological theories and concepts. While sociology emphasizes understanding social phenomena and their structural mechanisms, along with fostering critical thinking, public management focuses more on managing public affairs and executing policies, with an emphasis on practicality and efficiency. Therefore, in constructing the curriculum and setting educational objectives within the framework of public management, it is essential to enhance students' capacity to assimilate abstract concepts and develop critical thinking skills.

To address these challenges, incorporating concrete examples becomes key to aiding students in understanding foundational sociological knowledge. Using vivid representations in films and applying case study methods allows for the integration of abstract sociological theories with real-life social phenomena. This enables students to comprehend complex sociological concepts in contextualized settings, thereby improving learning outcomes. This innovative approach not only stimulates students' interest but also enhances their understanding and application of sociological principles, laying a solid theoretical foundation for their future work in older adults care management. This paper examines the design and implementation of sociology course pedagogy that integrates film analysis with case studies, offering insights for undergraduate teaching in interdisciplinary fields. The goal is to provide valuable references for fostering effective teaching practices in the intersection of sociology and applied disciplines like older adults care management.

## **2** INTEGRATING FILM ANALYSIS AND CASE STUDY METHODS IN SOCIOLOGY EDUCATION: APPLICATIONS AND PEDAGOGICAL FEASIBILITY

#### 2.1 Application and Feasibility of Combining Film Analysis and Case Studies in Sociology Courses

The use of films in sociology courses encompasses not only popular movies and television dramas but also documentaries and public sector-oriented programs. These diverse forms of media possess unique audiovisual advantages, offering rich social contexts that play a crucial role in teaching sociology[1]. Films can serve as a vital medium for knowledge dissemination and an effective teaching tool, providing students with an intuitive lens to analyze the interplay between society and human nature[2]. While watching films, students can also engage in analyzing social labels, visual representation, and societal phenomena, deepening their understanding of various social dimensions[3]. The case study method complements this approach by applying sociological theories to specific social scenarios, allowing students to adopt the role of social analysts. Through these experiences, they can explore the interplay between symbolic interactionism and diverse production relations[4]. This method encourages students to develop a deeper understanding of social phenomena and critical thinking, transforming abstract sociological theories into tangible social practices[5]. Additionally, case studies reveal the complexity of social phenomena and equip students to conduct

practical analyses in areas such as local governance through direct societal observations[6].

Combining case study methodology with films makes sociology teaching more engaging and effective, with significant pedagogical potential. Films are particularly suited for case analysis because of their media-specific attributes and emotional resonance[7]. These visual tools make social phenomena more accessible and relatable, enabling students to resonate deeply with the content and enhance their perception and analytical skills in real-world contexts[8]. Compared to traditional text-based cases, films integrate seamlessly into students' visual and cognitive experience, making case analysis more impactful and emotionally engaging[9].

The pedagogical feasibility of this combination can be illustrated through four key aspects:

#### 2.1.1 Enhancing the intuitiveness and dynamism of social analysis

The integration of case studies and films renders social analysis more vivid and dynamic. Unlike static text-based cases, films vividly depict characters and events, showcasing the dynamic nature of social phenomena. This approach highlights the complexity of societal interactions, enabling students to gain a deeper understanding of the interplay within social processes[10].

#### 2.1.2 Fostering empathy and immersion

Films evoke strong emotional resonance, allowing students to empathize with social phenomena in ways text-based cases cannot[11]. Since students often lack firsthand experience with many social phenomena, films provide a surrogate experience that immerses them in the social environment[12]. This compensates for their limited exposure while helping them better understand interpersonal interactions and societal processes within sociological theories.

2.1.3Overcoming Practical Constraints and Standardizing Learning Experiences

Limited time and space in classroom settings often preclude students from directly experiencing certain social situations. Films address this by offering a uniform contextual experience to all students, facilitating collective discussions and analysis[13]. This consistency establishes a shared foundation for case studies, enabling students to delve into social phenomena and their underlying theories from a common starting point[14].

#### 2.1.4 Enhancing observation and critical thinking

Combining films with case studies sharpens students' observational and analytical skills. By observing characters' behaviors, situational dynamics, and social interactions in films, students engage in multi-perspective analyses, fostering critical thinking[15]. This approach allows them to grasp social structures and stratification from diverse angles, making their understanding of sociological theories more multidimensional and comprehensive[16].

#### **3** TEACHING DESIGN AND METHODS FOR COMBINING FILM ANALYSIS AND CASE STUDIES

The pedagogical design for integrating film analysis with case studies in sociology courses involves a structured sequence: situational introduction, case analysis, group discussions, class presentations, and post-class reflections. This teaching cycle aims to closely tie sociological theories with real-life contexts, helping students bridge the gap between theoretical learning and practical analysis.

#### **3.1 Goals and Principles of the Teaching Design**

The teaching goals and principles serve as a guiding framework for this pedagogical innovation. The design follows the principles of "situational introduction, case analysis, and critical reflection," emphasizing student engagement and emotional resonance. The objective is to embed sociological theories into students' lived experiences, making the learning process both meaningful and practical.

Special attention is given to selecting films that resonate with the localized context of Chinese society. By incorporating culturally relevant examples, students are better equipped to understand and relate to societal phenomena, thereby enhancing the effectiveness of the learning experience.

#### **3.2 Case Selection for Teaching**

The selection of teaching cases is crucial in sociology courses. Appropriate cases can contextualize sociological concepts and theories, helping students connect abstract ideas to real-life scenarios. Films with relevant social backgrounds offer students a direct understanding of theories, evoke emotional resonance, and foster critical thinking. Particularly, films that reflect Chinese social phenomena allow students to relate them to their own experiences, deepening their comprehension of sociological theories and enhancing their social observation and analytical skills (Table 1).

Table 1 Examples of Sociological Concepts and Film Selections			
Key Sociological Concepts	Film Title	Summary of Film Content	Teaching Application
Social Conflict, Power Structure, Rule of Law vs. Rule of Man	The Story of Qiu Ju	A rural woman persistently petitions for justice, highlighting conflicts between local customs and legal awareness	Understanding the interaction between individual actions and social structures, and the tension between traditional norms and

			modern rule of law
Social Welfare, Healthcare Equity, Class Conflicts	Dying to Survive	A common man's struggle for access to affordable medicine, revealing issues of healthcare equity and welfare	Exploring the impact of social welfare on individuals and understanding the systemic challenges faced by vulnerable groups
Group Behavior, Social Norms, Power Dynamics, Prejudice	12 Angry Men	Jury deliberations that demonstrate the influence of group pressure on individual decision-making	Understanding group decision-making theories and the impact of social pressure on individual behavior
Social Stratification, Social Mobility, Cultural Capital	Slumdog Millionaire	An Indian youth changes his destiny through a quiz show, revealing class immobility and wealth disparity	Analyzing theories of social mobility and understanding the role of cultural capital in shaping social roles

#### 3.3 Teaching Process Design

The teaching process is structured to guide students through theoretical and practical learning. Key stages include:

#### 3.3.1 Course introduction

The introduction phase aims to immerse students in the course context and stimulate interest. Films are assigned as pre-class viewing, selected for their thematic relevance and emotional resonance. During class, the instructor briefly introduces the film's background and key content, providing students with a sociological framework to analyze the depicted social phenomena.

#### 3.3.2 Core case analysis

This stage forms the backbone of the teaching process. Through group discussions, students collaboratively apply sociological theories to analyze key sociological themes presented in the films, such as power dynamics, class structures, and cultural conflicts. Instructors facilitate the discussion, ensuring students effectively link theoretical knowledge with observed social phenomena.

#### **3.4 Teaching Methods and Techniques**

The course incorporates visual and interactive teaching methods to enhance understanding and engagement, transforming students from passive recipients to active participants.

Visual Learning: Films provide a vivid representation of social phenomena, fostering emotional resonance and critical thinking. Collaborative Learning: Group discussions, presentations, interactive Q&A sessions, and role-playing encourage multidimensional engagement.

Interactive Tools: Students practice analytical skills by identifying and critiquing social structures and behaviors depicted in the films, bridging theory and practice.

#### **3.5 Evaluation of Teaching Outcomes**

The course employs diverse assessment methods to evaluate knowledge acquisition, active participation, and critical thinking.

#### 3.5.1 Formative and summative assessments

Formative Assessments: Monitor students' progress through class discussions, group tasks, and interaction, evaluating participation and understanding.

Summative Assessments: Conducted at the semester's end, these include group reports, reflective essays, and classroom presentations to assess theoretical understanding and application.

#### 3.5.2 Comprehensive evaluation

Quantitative tools measure performance, while qualitative feedback fosters continuous improvement. Class presentations allow students to showcase their findings, receive feedback, and refine critical thinking and communication skills.

## 4 PRACTICAL TEACHING APPLICATION: CASE STUDY OF WEBER'S BUREAUCRACY IN CLASSROOM PRACTICE

Weber's theory of bureaucracy is a foundational concept in sociology, emphasizing institutionalization and legitimate authority. This course incorporates public sector programs to analyze public governance and the features and limitations of bureaucratic systems.

#### 4.1 Case Selection

Programs like Questioning Shandong and Sunshine Accountability focus on public accountability and administrative

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discussions. Unlike dramatized portrayals in films, these programs offer unembellished records of institutional operations, showcasing characteristics like legitimacy, hierarchy, institutionalization, and professionalism. They also reveal systemic inefficiencies, such as bureaucratic inertia and responsibility evasion, helping students critically evaluate bureaucratic structures.

#### 4.2 Teaching Steps and Classroom Activities

#### 4.2.1 Concept explanation and demonstration

The instructor begins by explaining Weber's bureaucratic theory, including characteristics such as rationalization, hierarchy, and clear functional divisions. Using a municipal park construction delay as a sample case, the instructor demonstrates how to analyze the bureaucracy's operations, identifying departmental responsibilities and the causes of delays.

#### 4.2.2 Students are guided to discuss

Strengths and Weaknesses of Bureaucracy: How do the organizational strengths, like procedural rigor, contribute to quality management?

Systemic Limitations: How do the inherent features of bureaucracy lead to inefficiencies, such as delays?

Proposed Improvements: What strategies could improve efficiency while preserving the advantages of bureaucracy, such as clear accountability mechanisms?

#### 4.2.3 Group assignments and preparation

Students are divided into groups, each selecting a case from the programs, such as platform development or river pollution control. Groups analyze these cases by focusing on power structures, role interactions, and institutional execution, preparing a detailed analysis for class discussion.

#### 4.3 Classroom Presentation and Group Discussion Analysis

In this segment, each group will present their analysis of a selected case study. Taking the case of "Smart Linyi Mall" as an example, the presentation focuses on the application of bureaucratic characteristics and problem diagnosis. Initially, group members will provide a brief background introduction, explaining that the Linyi municipal public sector invested heavily in building the "Smart Mall" to digitize traditional wholesale markets. However, five years later, the project failed to meet its goals, revealing typical issues inherent in bureaucratic operations. The group's analysis will be structured around the following three aspects:

#### 4.3.1 Manifestation of bureaucratic characteristics

The group highlights how the project exemplified Weber's defined bureaucratic characteristics during its implementation, such as clear functional division (e.g., platform development managed by Linyi Mall E-Commerce Technology Co., Ltd.) and hierarchical decision-making chains. However, this strict division also led to a "buck-passing" problem. Once the construction phase was completed, management responsibilities were transferred to public sector departments, leaving subsequent operations unattended. This illustrates role ambiguity and communication barriers within the bureaucratic system.

#### 4.3.2 Root cause analysis

The group explores the reasons behind the project's failure, citing inefficiencies in the bureaucratic system and an emphasis on formality over practical outcomes. Specifically, during platform development, managers focused solely on project completion while neglecting its usability, rendering the system a mere "showpiece." This reflects the rigidity and bureaucratic inertia that often plague such systems.

#### 4.3.3 Proposed improvements

The group offers several improvement strategies, such as introducing market-oriented management approaches to enhance operational flexibility and reduce over-reliance on administrative directives. Additionally, some members suggest establishing a more effective accountability mechanism to ensure clear responsibility at every stage, from development to operation.

Following the group presentation, peers from other groups raised questions regarding the content, particularly about the advantages and limitations of bureaucracy. For instance, one student asked whether it is possible to retain the normative strengths of bureaucracy in the "Smart Mall" project while mitigating issues like communication breakdowns and responsibility evasion. These discussions prompted group members to reflect further on their analysis while fostering a dialectical understanding of bureaucratic strengths and weaknesses among the entire class.

Subsequently, the instructor guided students to connect Weber's theory of bureaucracy with specific scenes from the project's implementation. For example, the instructor pointed out that the development process of the "Smart Mall" exemplified the limitations of Weber's concept of "rationalization." While each step had clearly defined procedures and divisions, the lack of flexibility and responsiveness to actual needs resulted in the project failing to achieve maximum efficiency. This analysis helped students understand the constraints of rationalization in real-world bureaucratic systems and encouraged them to think about strategies to address these challenges, thereby promoting improvements in public administration.

#### **5** CONCLUSION AND DISCUSSION

The integration of film-based learning and case analysis in sociology courses provides students with diverse

perspectives and vivid contexts, helping them ground theoretical concepts in complex social phenomena. This teaching approach significantly enhances students' comprehension and application of sociological theories, particularly in visualizing abstract ideas and linking them to real-life situations.

#### 5.1 Advantages of the Teaching Approach

The combination of films and case studies bridges the gap between abstract theories and concrete realities often found in traditional teaching methods. Through contextualized cases, students can better grasp sociological theories and develop keen insights and critical thinking about social phenomena. For instance, by analyzing the bureaucratic system in the "Smart Linyi Mall" case, students gain a tangible sense of the far-reaching effects of institutional frameworks on social actions.

#### 5.2 Challenges and Solutions

Despite its unique advantages, this teaching method also faces challenges, such as selecting appropriate films and ensuring students engage deeply rather than passively watch. To address these issues, instructors should provide detailed viewing guides and discussion prompts to align the viewing process with clear learning objectives. Moreover, collaborative group learning and instructor-led facilitation are critical to the effectiveness of this method. Employing diverse teaching strategies to stimulate student participation and agency can effectively overcome these challenges.

#### **5.3 Implications for Future Teaching**

Looking forward, sociology teaching can further explore how other multimedia resources, such as documentaries and social experiment recordings, can be integrated into courses to enrich content. Additionally, incorporating students' fieldwork experiences into the curriculum can extend learning from the classroom to the field, achieving a holistic integration of classroom learning, social investigation, and civic engagement.

In conclusion, the innovative combination of film-based learning and case analysis not only broadens students' theoretical understanding but also strengthens their awareness of social realities. For students in older adults care service management programs, this novel teaching approach lays a solid foundation in theory and practical skills, equipping them for future careers in public administration and social services.

#### **COMPETING INTERESTS**

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## ARTISTIC CHARACTERISTICS AND CREATIVE REGENERATION OF RURAL FOLK ARTISTS IN ZHONGLU, DANBA

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Abstract: Traditional village cultures are undergoing profound transformations driven not only by the gradual evolution of historical time but also by the interplay and reconstruction of multiple cultural influences under the impact of modern technology and informatization. In this cultural crossroads, rural folk artists, as primary creators of local aesthetics, face significant challenges in preserving and continuing their artistic traditions. The inheritance of traditional craftsmanship must align with the aesthetic standards of modern society while meeting the demands of a market economy. Zhonglu Township in Danba County, located in Ganzi Prefecture, Sichuan Province, serves as a typical case study of this cultural reconstruction process, given its distinct status as a traditional village profoundly affected by modern multicultural influences. Drawing on fieldwork in this Jiarong Tibetan settlement, this study delves into the artistic characteristics of rural folk artists and the processes of their creative regeneration. It explores how traditional arts can sustain their vitality and economic value in the face of modern societal challenges.

Keywords: Zhonglu; Danba; Rural folk artists; Artistic characteristics; Creative regeneration

#### INTRODUCTION

Traditional villages, as an integral part of China's cultural heritage, embody profound historical memory and rich cultural value. The traditional villages of Zhonglu Township in Danba County, Ganzi Tibetan Autonomous Prefecture, stand out with their distinctive geographic setting and cultural resources. The intertwining of Tibetan village layouts, natural landscapes, and historical culture has given rise to a unique cultural ecosystem. These exceptional resources not only highlight local ethnic characteristics but also provide an ideal case for investigating the artistic characteristics and creative regeneration of rural folk artists.

In these villages, many residents are not only agricultural laborers but also creators of folk art. Beyond their farming duties, they integrate observations and emotions from daily life into their songs, dances, crafts, and architectural works, presenting their understanding of beauty and their interpretations of ethnic culture through unique artistic forms. These works not only encapsulate distinct ethnic aesthetics but also document the historical and cultural transformations of the villages. However, with the accelerating pace of modernization, traditional villages face a dual challenge of preservation and development: how to achieve sustainable development while safeguarding traditional culture remains an urgent issue.

Although scholars such as Hu Dan, Li Jiaxi, and Wei Jiajia have explored the aesthetic characteristics of traditional settlements from perspectives like architectural forms, proportional relationships, and craftsmanship, research on the unique artistic traits of rural folk artists and the mechanisms of creative regeneration amidst contemporary rapid transitions remains relatively underdeveloped. Li Xianglin [1] emphasized that folk art constitutes the core of traditional village culture, embodying a "spirit of craftsmanship" that not only serves social life but also showcases exquisite creative skills. With the advance of urbanization, the social structures and cultural ecosystems of traditional villages have undergone profound changes, giving rise to new dynamics in the reproduction of folk art. The artistic traits of rural folk artists and the mechanisms of traditional provide a crucial lens for understanding the cultural renewal of traditional villages.

Against this backdrop, this study focuses on the multifaceted impact of modernization on traditional villages. On the one hand, the influence of modern lifestyles challenges the transmission of traditional crafts. On the other hand, the commercialization driven by tourism development risks diluting the authenticity of village culture. Therefore, this research centers on how to preserve and perpetuate the artistic characteristics of rural folk artists in a modern context while fostering the regeneration of their works—a core issue addressed in this paper.

#### 1 ZHONGLU IN DANBA AND ITS RURAL FOLK ARTIST COMMUNITY

#### 1.1 Geographical and Historical-Cultural Context of Zhonglu in Danba

Zhonglu Township, located in a high-altitude mountainous gorge with an average elevation of 2,300 meters, features a landscape dominated by alternating ridges and valleys. The subtropical, low-latitude, high-altitude monsoon climate has nurtured abundant natural resources, including farmland, mountains, forests, meadows, streams, and canyons. Zhonglu Township in Danba County is renowned for its dense concentration of ancient watchtowers, which are among the

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best-preserved in terms of number and condition. Characterized by Jiarong Tibetan-style residences, the architecture employs traditional dry-stone walling techniques. These dwellings, combined with ancient watchtowers, religious structures, and village layouts, form a unique cultural landscape of high aesthetic value, earning Zhonglu the title "Paradise for Explorers."

According to local legends, the ancestors of the early inhabitants migrated here from Tibet with sheep, settling and thriving through a combination of pastoralism and farming. Zhonglu is also a focal area for the relics of the ancient Dongnu Kingdom and prehistoric sites, including ancient human cultural sites and stone coffin tomb clusters, which are listed as provincial-level protected heritage. This region retains numerous vestiges of the Dongnu Kingdom, emphasizing the cultural theme of "female supremacy." Danba County represents a confluence of Jiarong Tibetan culture and Dongnu culture, uniquely preserving the "Coming-of-Age Ceremony for Women," known locally as Gisa. This ritual symbolizes a girl's transition to adulthood and her capability to independently manage household affairs, reflecting the region's distinctive matriarchal culture and rich Jiarong Tibetan rites.

#### **1.2 Historical Development of Rural Folk Artists**

Rural folk artists in Zhonglu, Danba, have historically been an integral part of the traditional culture of Jiarong Tibetan villages. They are both primary laborers in agricultural production and vital contributors to artistic creation, crafting numerous awe-inspiring works of art through their skilled hands.

#### 1.2.1 Social status and identity

In Zhonglu, rural folk artists hold a special social status. They are not only highly skilled artisans but also custodians and transmitters of village culture. Owing to their outstanding artistic contributions, they enjoy significant prestige and respect within the community. Their works, such as intricately crafted Tibetan dwellings and vibrantly colored ethnic costumes, are treasured as cultural gems of the village. Folk artists also take great pride in their identity, viewing themselves as guardians of village culture who perpetuate and celebrate Tibetan traditions through their artistic endeavors.

#### 1.2.2 Traditional pathways and methods of artistic transmission

The artistic traditions of Zhonglu's rural folk artists are transmitted through diverse means, primarily familial inheritance and mentorship. Familial inheritance involves the intergenerational passing of artistic skills within families, leading to the development of distinct artistic schools and styles. Mentorship entails skilled artisans training apprentices, imparting their expertise and experience to younger generations. Additionally, Zhonglu retains a wealth of oral literature and folklore, which serve as important vehicles for artistic transmission. These stories and songs provide a rich narrative context, enabling the continuous growth and prosperity of local folk art.

#### 1.3 Roles of Folk Artists in the Community

Rural folk artists play an indispensable role in Zhonglu, contributing significantly to community life and development. They act as both cultural inheritors and drivers of economic and cultural progress.

Firstly, through their artistic creations and sales, they generate economic income for the village. Secondly, folk artists are pivotal in preserving and promoting village culture. By organizing cultural events and teaching their craft, they pass on the traditions of the community to younger generations, ensuring cultural continuity and growth. Moreover, they actively participate in cultural initiatives such as constructing dwellings, temples, and ritual items, thereby enhancing the vibrancy of village culture.

Finally, folk artists contribute to fostering social harmony and stability within the community. Their artistic creations and collaborative efforts strengthen bonds and a sense of belonging among villagers, promoting communal harmony and stability. Their works also serve as bridges for emotional exchange and communication, deepening friendships and solidarity within the community.

#### 2 CHARACTERISTICS OF FOLK ARTISTS IN ZHONGLU, DANBA

Ernst Gombrich [2] famously remarked, "There is no such thing as art; there are only artists." When studying folk art in traditional villages, the focus must shift to its creators. In small-scale societies, artists are not only makers of artworks but also cultural practitioners fulfilling specific social roles. Understanding their artistic traits, the transmission of their skills, and their roles within social networks is crucial to uncovering the essence of traditional art. From an anthropological perspective, this analysis deepens our comprehension of their identities, social functions, and how their works regenerate and carry cultural significance in specific contexts.

#### 2.1 Distinctive Features of Artistic Creation

#### 1.1 Themes and Artistic Style

The themes of Zhonglu's folk artists often draw from the local natural landscape, folk customs, and religious beliefs. These themes reflect their deep affection for their living environment and a strong sense of local cultural identity. Their style embodies the unpretentious beauty of Jiarong Tibetan culture, with artworks characterized by vibrant colors and rustic forms. Through visual arts and decorative crafts, they convey a rich cultural ambiance.

#### 1.2 Craftsmanship: Tradition and Innovation

The *dry-stone building technique* employed in constructing the ancient watchtowers exemplifies the artisans' ability to use natural materials to create structures that are both durable and aesthetically pleasing. This craftsmanship has been passed down through familial and apprentice-based traditions within the village.

In recent years, the rise of cultural tourism has spurred innovation. For example, some artisans collaborate with experiential learning programs to re-enact traditional techniques like stone-stacking for watchtower construction, engaging architecture students and enthusiasts. This has fostered new art forms rooted in traditional techniques, ensuring the regeneration of traditional crafts in contemporary contexts.

#### 2.2 Role of Local Knowledge in Artistic Creation

#### 2.1 Core values of traditional craftsmanship

The artisans' skills reflect not only their creativity but also their deep reservoir of local knowledge. Their choices of materials, methods, and final presentations embody an understanding and respect for the surrounding natural resources. This ecological ethos underpins their handcraft traditions, creating a symbiotic relationship between the environment and culture.

#### 2.2 Interaction with the natural environment

Local rituals vividly illustrate the interplay between humans and nature. The annual festival on the 29th day of the third lunar month is a notable example. Based on the traditions of the Mount Moerdo deity, villagers perform unique *circumambulation* rituals to pray for health and happiness, expressing their profound connection to nature. These rituals transform natural landscapes into cultural landmarks imbued with spiritual meaning, strengthening the emotional ties between the community and its environment.

#### 2.3 Social and Cultural Significance of Artistic Traits

In Zhonglu, art transcends aesthetics, serving as a symbol of identity and cultural belonging. Folk art plays a pivotal role in local rituals and festivals, reinforcing collective identity through cultural activities.

For instance, the "Mu-shan Song Ritual" (*Ding Zanshan Ge*) is a traditional ceremony where boys, around 12 or 13 years old, don *Mu-shan* (decorative Tibetan robes) in an initiation rite. Guided by esteemed elders, the boys sing love songs in front of young girls, vying for their admiration. This ritual is not only a declaration of affection but also a symbolic integration of youth into the community.

Similarly, the local *coming-of-age ceremony* for girls is rich with cultural and artistic symbolism. Guided by elder artisans, unmarried girls wear ornaments depicting deities and perform dances at the foot of Mount Moerdo. Accompanied by traditional performances, these rites vividly convey Jiarong Tibetan history and cultural memory, reinforcing villagers' sense of identity and heritage.

# **3** THE REGENERATION OF FARMER ARTISTS' WORKS IN DANBA ZHONGLU IN THE MODERN CONTEXT

#### 3.1 Harmonizing Inheritance and Innovation

#### 3.1.1 The regeneration and innovation of traditional works

#### The continuous transmission and regeneration of cultural elements:

In the residential architecture of the Danba Zhonglu area, a substantial amount of the original features of Jiarong Tibetan culture has been preserved, with efforts made to protect and revive the unique characteristics of ethnic architecture. While modern materials are used in new constructions, the traditional style of the residential houses is strictly adhered to, organically integrating ancient watchtowers with living spaces. These homes have become family museums that showcase traditional lifestyles, deeply connecting life with art and ensuring the "living" inheritance of Jiarong culture.

#### The modern regeneration of farmer artists' works:

While inheriting ancient craftsmanship, local artists actively transform artistic content into new creations that align with modern aesthetics. For example, traditional *shan songs* have undergone innovations in content and form. This artistic form not only conveys the life perceptions of Zhonglu villagers but also incorporates contemporary elements into its expression, continuing to attract the attention of young audiences.

#### 3.1.2 Challenges and opportunities in regeneration

#### **Balancing inheritance and innovation:**

Although a large number of ancient watchtowers and traditional art forms have been preserved, farmer artists face challenges in exploring the balance between inheritance and innovation. On the one hand, many young people leave the villages for education, leaving mostly older artists behind. While the older generation has an advantage in maintaining cultural stability, their creative vitality is relatively limited. This generational change has made it challenging to pass on art forms such as *shan songs*.

#### **Opportunities through education and cultural return:**

Although the outflow of young people reduces local creative capacity, higher education levels may enable the younger generation to revive traditional culture through innovative means. The broadened perspectives and introduction of

modern technologies (such as digital tools) brought by education create new opportunities for local cultural industrialization, enhancing the competitiveness of Danba's traditional arts in modern markets.

#### **3.2 Influencing Factors**

## 3.2.1 External influences: the role of market, technology, policy, and tourism The promotion of cultural tourism

With the rapid development of the cultural tourism industry, market demand for traditional art works continues to grow. This change drives farmer artists to reproduce and innovate their works, combining traditional art forms with modern markets to create more appealing works that meet tourist demand. For example, in Danba Zhonglu, educational travel has enhanced opportunities for local artists to showcase their artistic characteristics and works, while also increasing the local community's appreciation of its cultural heritage.

#### The impact of digital platforms

The rise of social media and digital platforms provides farmer artists with new channels for dissemination. Through these platforms, artists can widely showcase their works, communicate directly with consumers, gain market feedback, and promote their art on a larger scale. In Danba Zhonglu, these digital platforms have drawn the attention of modern youth to admire and appreciate folk arts such as ancient watchtowers, Guozhuang dance, and *Jisa*. As a result, these traditional artistic forms have been able to survive and develop in modern society.

#### The role of policy support

Policies and funding support from the official and non-official organizations are crucial to the creative reproduction of farmer artists. Through cultural project funding, training, and promotional activities in cultural tourism, artists can acquire the necessary resources and support to sustain and develop their traditional art. This not only helps artists improve their skills but also provides economic security for the regeneration of their works.

#### 3.2.2 Internal influences: community culture and family inheritance

#### Changes and persistence in intergenerational transmission

In the creation of farmer artists, family and community cultural backgrounds play a vital role. With modern societal changes, the younger generation's understanding and recognition of traditional art face challenges. On the one hand, the transmission of traditional techniques may weaken due to external influences. On the other hand, many artists remain committed to preserving these cultural roots to ensure the vitality of traditional arts in modern society.

#### The influence of family on artistic characteristics

Family largely influences artists' artistic characteristics. Artists who grow up in families rich in artistic traditions are more likely to absorb traditional techniques and develop unique artistic styles. Our research involved two rounds of fieldwork over two weeks in the core areas of Danba, focusing on Gikai Village, Kegyi Village, Garenyi Village, and Bose Long Village. We selected 17 representative *shan song* singers and Guozhuang dance performers, along with 6 outstanding intangible cultural heritage inheritors, to participate in a seminar discussing the original features, preservation progress, and current state of intangible cultural heritage in the traditional villages of Jiarong Tibetans in Danba.

Among these artists, most came from the same family or were relatives, forming complex kinship networks. These close relationships not only facilitated artistic exchange and transmission but also influenced artists' understanding and creative styles of traditional art. The family's mechanism of artistic inheritance allows the younger generation to combine their traditional education with their own life experiences, thereby creating art with local characteristics and a sense of the times.

#### 3.2.3 Artists' personal factors: creativity and adaptability

#### Understanding tradition and re-creation

Artists' creativity and adaptability play a central role in the reproduction of their works. How they understand tradition and combine it with contemporary elements is key to the survival and development of their works. Artists who effectively integrate tradition and modernity often succeed in preserving cultural roots while creating art that aligns with contemporary aesthetics.

#### Creative motivation and personal characteristics

Artists' personal characteristics and creative motivations directly influence the quality of their works and their market acceptance. Many artists, driven by love for their ethnic traditions and a sense of responsibility, strive to express cultural identity and personal stories in their creations. This internal drive often leads to profound and expansive artistic works. According to field research, many *shan song* and Guozhuang dance works in Danba Zhonglu are improvisational creations inspired by the artists' emotions at the time, reflecting their unique personalities and emotions. For instance, singers with different temperaments display diverse emotional layers and themes in their lyrics, while the physical expressions in Guozhuang dance demonstrate a combination of intensity and grace. These personalized expressions not only enrich the content of artistic works but also enhance their market appeal.

#### 4 MAHE KANGGAU AND THE ART OF DIMBU FOLK SONGS

#### 4.1 Mahe Kanggau and Dimbu Folk Songs

As a significant cultural expression of Zhonglu in Danba, Dimbu folk songs underscore the intimate connection between traditional villages and folk arts. Professor Li Xianglin [1] noted that traditional villages serve as the "cultural

matrix" of China's rural culture, while folk arts represent their fundamental and most iconic cultural essence. Against this backdrop, studying Mahe Kanggau, a farmer-artist from Zhonglu, and her art of Dimbu folk songs, not only deepens the understanding of the inheritance and reproduction of folk art in traditional villages but also provides a vivid case for intangible cultural heritage preservation and innovation.

Mahe Kanggau is the provincial-level intangible cultural heritage representative of Dimbu folk songs in Moerduo Township, Danba County, Ganzi Prefecture, Sichuan Province. With profound artistic accomplishment and creative practice, she integrates this ancient art form with the aesthetic aspects of everyday life in her environment, showcasing unique artistic characteristics. Her Dimbu folk songs weave together the natural landscapes, folk customs, and religious beliefs of Danba, embodying rich cultural connotations, vitality, and artistic appeal.

#### 4.2 Artistic Journey and Transformation

Mahe Kanggau grew up in the agrarian culture of Danba, and her artistic creations are deeply rooted in everyday life and village culture. Our first encounter with her was facilitated by another folk artist, Jiaza Wengchong. She wore traditional Tibetan attire and a distinctive headdress, singing Dimbu folk songs in a duet with Jiaza Wengchong while working in the fields. Her natural artistic charisma was evident. Though her Mandarin was limited, her Dimbu songs became her primary medium for expressing emotions and thoughts. Through her singing and storytelling, her profound love and dedication to her homeland and ethnic culture were palpable.

Her artistic journey has been both a process of preserving tradition and a practice of innovation and adaptation. Mahe Kanggau skillfully combines traditional elements with contemporary aesthetics, creating Dimbu folk songs that retain their rich ethnic characteristics while appealing to modern tastes. This artistic transformation revitalizes Dimbu folk songs in contemporary contexts and exemplifies the adaptive development of folk arts in modern society.

Additionally, she actively embraces modern technologies and aesthetic paradigms, blending traditional culture with contemporary settings to explore the dissemination and expression of Dimbu folk songs in the digital age. This effort not only sustains the traditional vitality of the art but also broadens its application and communication pathways in contemporary cultural contexts.

#### 4.3 Community Feedback and Social Impact

Mahe Kanggau's artistic practice has generated positive impacts both within her community and beyond. Her Dimbu folk songs are cherished by local villagers and regarded as an essential expression of Danba's village culture. The community supports her artistic endeavors and actively participates in her cultural activities, making Dimbu folk songs a crucial cultural link that fosters community cohesion.

On a broader societal scale, Mahe Kanggau has ensured that Dimbu folk songs gain recognition in the fields of intangible heritage exhibitions and cultural exchange. She has frequently participated in traditional cultural exhibitions to promote this art form and has advanced the integration of intangible heritage preservation with education through her personal efforts. Her work not only facilitates the modern transformation of traditional culture but also injects vitality into the local economy and cultural industries.

Through her artistic creations and cultural advocacy, Mahe Kanggau has made significant contributions to the inheritance and innovation of Dimbu folk songs. Her case demonstrates that traditional art can achieve sustainable development only when its authenticity and core values are respected while being harmonized with contemporary life and aesthetic demands. Her practice provides valuable insights and experiences for the reproduction of folk arts in traditional villages.

#### 5 CULTURAL VALUE ASSESSMENT OF FARMERS' ARTWORKS

#### 5.1 Cultural Heritage Evaluation

The works of farmer-artists hold an irreplaceable role and significance in the preservation and transmission of cultural heritage. These works not only authentically document and reflect local history, customs, and culture, but also carry rich intangible cultural heritage connotations. Through generational transmission, they have become an essential part of local culture, showcasing deep historical accumulation and cultural memory.

Between 2021 and 2022, I participated in a census on the historical elements of traditional villages in the Zhonglu area of Danba County, Ganzi Prefecture. The scope of the survey covered the historical changes of Tibetan houses, traditional Tibetan craftsmanship, the construction techniques of watchtowers, historical environmental factors, ancient trees, and the distribution of intangible cultural heritage. The results of the survey showed that most of the cultural heritage in the Zhonglu area has been passed down through generations by local farmer-artists. Among them, the "stone stacking technique" used in the construction of ancient watchtowers, Dimbu folk songs, and the Peacock Guozhuang dance, as important intangible cultural heritage elements, are all created and maintained by farmer-artists. These cultural transmitters are not only guardians of these skills but also vital driving forces for cultural reproduction, with immeasurable value. Many of these inheritors have been recognized as representative inheritors of intangible cultural heritage in Sichuan Province.

#### 5.2 Accumulation of Cultural and Social Capital

The works of farmer-artists in the Zhonglu area also demonstrate significant value in promoting the integration of local culture and economic development. Through the exhibition and sale of their works, these traditional art forms have gradually transformed into economic capital. This transformation has not only brought considerable material benefits to the artists themselves but also further enhanced their cultural confidence and creative enthusiasm. The accumulation and transformation of this cultural capital align closely with Pierre Bourdieu's theory of cultural capital, where cultural resources function across various domains, such as the economic and social spheres, laying a solid foundation for the sustainable development of local culture.

Furthermore, these works have gradually accumulated social capital through exhibitions and promotion. On one hand, by showcasing their works through multiple channels, farmer-artists have expanded their recognition and acceptance within a wider social group. On the other hand, the living transmission and dissemination of cultural heritage have enhanced community cohesion, giving local culture new social significance and vitality.

#### 5.3 Aesthetic and Aesthetic Value

The works of farmer-artists in the Zhonglu area not only possess profound cultural value but also exhibit exceptional aesthetic and aesthetic value. These works strictly adhere to traditional craft processes and ethnic aesthetic standards, incorporating unique cultural elements of the Jiarong Tibetan culture, presenting a strong local flavor and ethnic style. Whether it is the rigor and craftsmanship of the ancient watchtower stone stacking technique or the liveliness and beauty of Dimbu folk songs and the Peacock Guozhuang dance, these works highlight the artistic charm of traditional culture.

At the same time, these art forms provide valuable resources for aesthetic education for young people. Through the display and education of cultural heritage, the younger generation not only experiences the aesthetic beauty of traditional art but also strengthens their identification with and love for local culture. This, in turn, stimulates their interest in and sense of responsibility for cultural transmission. This intergenerational educational role further enriches the cultural significance of the farmer-artists' works.

#### 6 INTERACTION BETWEEN FARMERS' ART CREATION AND THE MARKET

#### 6.1 The Role of Market Demand

Contemporary market demand has a significant influence on the creative choices of farmer-artists. Within the framework of sustainable development for traditional villages, finding key ways to drive artistic regeneration is crucial, and the introduction of the cultural and creative industries is undoubtedly an effective lever. By integrating the concept of creative industries into the process of traditional artistic reproduction, it is possible to infuse folk skills with new vitality, making their products more attractive and economically valuable in the modern market. This model requires systematic training for artists to enhance their innovative capabilities, enabling them to meet the demands of contemporary cultural industries while maintaining their creative enthusiasm. In Danba Zhonglu, the introduction of experiential learning travel projects has brought new perspectives and inspiration to the farmer-artists, driven by the curiosity and enthusiasm of young students. Interaction with the younger generation from outside the community not only provides opportunities for the transmission of traditional skills but also stimulates the artists' creative impulses, making the artistic reproduction process more dynamic and vibrant.

#### 6.2 Tension and Balance Between Commercialization, Authenticity, and Cultural Preservation

In the context of globalization and modernization, the tension and balance between commercialization, authenticity, and cultural preservation have become central issues in the protection of traditional arts and cultural heritage. Farmer-artists and local communities face a dilemma: on one hand, excessive commercialization may dilute the cultural purity and uniqueness of their works; on the other hand, a strict adherence to authenticity might limit the market acceptance and spread of the art forms. This contradiction forces artistic works to maintain their core cultural values while entering the market through branding and promotion strategies, achieving both cultural and economic value.

On a theoretical level, "authenticity" is a key issue in cultural preservation. Smith [4] argues that the authenticity of cultural heritage should align with the deep cultural connections of the community, while Merryman [5] emphasizes that the innovation of traditional culture should be carried out while retaining its core values in order to achieve cultural sustainability. This viewpoint suggests that cultural innovation is not a departure from tradition, but rather a continuation and adaptation of its vitality.

In practice, local department and communities create favorable conditions for cultural transmission and innovation through policy support and financial guidance. For instance, encouraging the implementation of experiential learning travel projects that integrate traditional arts with tourism and education not only promotes local economic development but also revitalizes traditional culture. In this process, intergenerational transmission and the integration of social culture inject new momentum into the creative practices of farmer-artists, allowing them to incorporate their arts into education and commercial sectors while preserving traditional craftsmanship. This drives the modern adaptability of culture.

Therefore, the commercialization and innovation of culture require careful balance. It is essential to avoid losing cultural roots due to over-marketization, while also activating cultural vitality through moderate innovation, allowing for the coexistence of authenticity and economic value.

#### 7 PROTECTION POLICIES AND SUPPORT MECHANISMS

To promote the protection and inheritance of folk cultural arts, Danba County in Ganzi Prefecture, Sichuan Province has implemented a series of comprehensive protection policies and support mechanisms. These measures encompass various aspects, including legal and regulatory safeguards, financial investment, talent cultivation, cultural excavation, publicity and promotion, and the integration of culture and tourism, forming a relatively complete support system.

#### 7.1 Legal and Regulatory Safeguards

Danba County has based its cultural protection work on laws and regulations to ensure that protection is carried out according to legal frameworks. The implementation of the *Ganzi Tibetan Autonomous Prefecture Intangible Cultural Heritage Regulations* has brought the folk cultural arts of Danba County under the legal system, providing effective institutional guarantees for various intangible cultural heritage projects. This not only helps clarify protection responsibilities but also provides a legal basis for inheritors and related institutions in the field of cultural protection.

#### 7.2 Financial Investment and Support

The Danba County has provided substantial material support for cultural heritage protection through special funds and project funding. For instance, financial support has been provided for the establishment of databases for *Dingmaishan Songs* and *Guozhuang Dance*, as well as for the surveying, registration, and application for heritage status of watchtowers and villages. These financial investments ensure the systematic protection of cultural resources and the smooth implementation of inheritance efforts.

Additionally, the introduction of social capital has provided new momentum for the revitalization and utilization of folk cultural arts. By encouraging businesses to participate in the development of intangible cultural heritage creative products, it is expected that 25 types of cultural and creative products will be launched by the end of 2024, further promoting the integration of cultural arts with the market economy and achieving dual benefits in both economy and culture.

#### 7.3 Talent Cultivation and Educational Inheritance

Danba County emphasizes the training of cultural inheritors and intergenerational transmission of skills. Through organizing various training programs and cultural inheritance activities, the professional abilities of inheritors are enhanced. For example, training in *Jiarong embroidery* and *Tibetan watchtower construction techniques* not only imparts traditional crafts but also focuses on enhancing the trainees' understanding of the cultural significance, fostering cultural confidence and responsibility.

In terms of educational inheritance, Danba County plans to adapt folk songs, dances, and other intangible heritage content into school-based curricula to bring folk cultural arts into schools. This educational approach provides opportunities for young people to engage with and learn about traditional culture, effectively nurturing the next generation's interest in and identification with local culture.

#### 7.4 Cultural Excavation and Documentation

Danba County has systematically carried out a cultural resource survey, compiling a comprehensive record of folk cultural arts and establishing relevant databases. For example, the construction of a database for *Guozhuang Dance* and *Mountain Songs* not only provides important resources for future research but also lays the foundation for the digital protection of cultural heritage. At the same time, cultural materials such as albums on ancient watchtowers and collections of folk stories have been published to further enrich the forms and connotations of cultural inheritance.

#### 7.5 Publicity, Promotion, and Cultural Exchange

Danba County has continuously expanded the social influence of folk cultural arts through multi-level publicity and exchange activities. The county has organized and participated in various cultural festivals and exhibitions, such as the 5th *China Chengdu International Intangible Cultural Heritage Festival*, which showcased the charm of Danba's cultural heritage. Additionally, through media programs like *Seeking Beauty in Danba*, the use of modern communication methods has enhanced the visibility of Danba's culture. Furthermore, the planning and implementation of cultural and tourism brand activities, such as *Flowers Bloom in Danba*, *Coming for Pears*, has facilitated the deep integration of cultural arts and the tourism industry, creating a positive cycle where "culture promotes tourism, and tourism brings culture."

#### 7.6 Discussion

The participation of non-official organizations and universities has injected new vitality into the protection and inheritance of Danba County's folk cultural arts. For example, the *College of Music and Dance* at Sichuan Minzu University has provided academic support for the protection of *Dingmaishan Songs* through fieldwork. Additionally,

the Chenghua District in collaboration with Chengdu Television launched the Seeking Beauty in Danba program to further enhance the dissemination of Danba culture.

#### 7.7 Cultural Ecological Protection and Integration of Culture and Tourism

Jiarong culture has successfully been approved as a provincial-level cultural ecological protection experimental zone, creating favorable conditions for the survival and development of folk cultural arts through the holistic protection of cultural ecology. This model of comprehensive protection emphasizes the diversity of culture and the sustainability of inheritance, providing innovative ideas for the protection of intangible cultural heritage. At the same time, Danba County has achieved notable results in integrating culture and tourism, such as setting up an experience zone for the ancient Tibetan watchtower and house construction techniques at the *Jiaju Scenic Area*, where tourists can participate and deepen their understanding and love for folk cultural arts.

#### 7.8 Incentive Mechanisms and Sustainable Support

Danba County has established incentive mechanisms through the recognition and funding policies for intangible heritage inheritors to encourage them to engage in protection and inheritance work. At the same time, reward systems have been set up to honor individuals and groups that stand out in cultural inheritance, creating a favorable social atmosphere for the transmission of folk cultural arts.

#### **COMPETING INTERESTS**

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

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# BASED ON SIX SIGMA ANALYSIS: ON THE LEAN STRATEGY OF PARK QUEUING IN BEIJING ZOO

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**Abstract:** The purpose of this report is to use industrial engineering and lean management methods to improve the queuing congestion in scenic spots, solve the problem of long waiting time, and improve the efficiency of tourist experience and scenic management. At present, the long queue waiting in popular scenic spots has become a problem that seriously affects the tourist experience and the operation efficiency of scenic spots. We analyze the current situation of queuing through Six Sigma, and then optimize the queuing process, aiming to reduce the waiting time, improve the tourist experience, increase the service quality of the scenic spot and improve the competitiveness and management efficiency of the scenic spot. This report will elaborate on the background of the topic selection, the improvement process, and the expected results. Through this study, we expect to provide a feasible queuing management scheme for tourist attractions to improve the tourist experience and improve the overall operational efficiency of scenic spots.

Keywords: Scenic spot queuing; Process optimization; Tourist experience; Lean improvement

#### **1 INTRODUCTION**

In modern society, with the rapid development of the tourism industry, an increasing number of tourists are flocking to various tourist attractions, making the issue of queuing at these sites increasingly prominent. Long waiting times in queues can cause inconvenience to visitors, not only reducing their travel experience and satisfaction but also potentially having a negative impact on the image and economic benefits of the attractions. Therefore, optimizing the queuing management at tourist attractions has become an urgent problem to be addressed.

This report takes Beijing Zoo as a case study and applies industrial engineering and lean management methods to optimize the queuing process at the attraction, aiming to enhance visitor experience, reduce waiting times, increase the attraction's appeal, and simultaneously improve management efficiency. This not only helps to improve the travel experience for visitors but also enhances the competitiveness and sustainable development capabilities of the attraction. Through in-depth research and analysis, we propose a series of improvement measures to enable visitors to tour the zoo more smoothly and fully enjoy the fun and educational significance it offers.

Firstly, we conducted an analysis of the current situation and background investigation. Data from the Ministry of Culture and Tourism's official website revealed that the willingness of residents to travel, business confidence, and the comprehensive index of tourism economic operation have all reached the best levels in the past three years. However, the significant increase in tourist numbers and the concentrated peak tourism season have led to insufficient reception capacity at various attractions, making the queuing issue at these sites increasingly prominent. Long waiting times in queues have become an inescapable problem in many popular attractions, with Beijing Zoo, which ranks among the top three in total visitor reception during the "May Day" holiday according to data released by the Beijing Park Management Center in 2023, facing an even more severe issue.

Secondly, we analyzed the identified problems and improved the process. After identifying the problem, we proceeded to analyze and resolve it. The first step was to clarify the scope, objectives, and key project details. The second step involved collecting and recording the initial data required to establish a foundation for the problem. The third step was to analyze the obtained data using various Six Sigma tools, processing the data and visualizing it to identify the causes of long queues at tourist attractions. The fourth step was to formulate various methods based on the previously identified causes and implement them, which effectively improved the situation of long queuing times at the attraction. The fifth step was to develop a control plan to monitor and manage the process, ensuring that the solutions to the problem are maintained in the long term to achieve lasting improvements.

#### **2** BACKGROUND OF THE TOPIC

According to data from the official website of the Ministry of Culture and Tourism, the number of domestic tourism trips in the first half of the year reached 2.384 billion, a year-on-year increase of 63.9%; domestic tourism revenue was 23 trillion yuan, a year-on-year increase of 95.9%. Whether it is the willingness of residents to travel, business confidence, or the comprehensive index of tourism economic operation, they have all reached the best levels in the past three years. The China Tourism Academy forecasts that the number of domestic tourists for the whole year of 2023 will be 5.5 billion, and domestic tourism revenue will exceed 50 trillion yuan, respectively recovering to more than 90% and 80% of the levels in 2019 [1].



According to data from China Unicom, the number of tourists nationwide during this year's "May Day" holiday reached 200 million, an increase of 26.65% compared to the same period in 2019 (Figure 1).

Figure 1 Trend of National Tourist Numbers during the "May Day" Holiday

After more than three years of pandemic control, the public is in urgent need of a trip to release their long-suppressed enthusiasm for travel. Data from China Unicom shows that long-distance travel was more popular during this holiday, with the average travel distance in cities across the country reaching 441.69 km (Figure 2).



Figure 2 Proportion of Travel Distances during the "May Day" Holiday

The above data indicates that China's tourism economy has reached a strategic turning point and has entered an irreversible new channel of recovery and upward momentum. Therefore, we have reason to be more optimistic about the tourism economy in the second half of the year and even over the next three years.

However, with the recovery of the tourism economy, the significant increase in tourist numbers and the concentration of the peak travel season have led to insufficient reception capacity at various attractions, making the queuing issue at these sites increasingly prominent. Long waiting times in queues have become an inescapable problem in many popular attractions. Excessive queuing times may cause inconvenience to visitors, not only reducing their travel experience and satisfaction but also potentially leading to visitor loss, affecting the image and economic benefits of the attractions.

The official website shows that Beijing Zoo is located on Xizhimen Outer Street, Xicheng District, Beijing, China, adjacent to the Beijing Exhibition Center and the Moscow Restaurant, covering an area of about 86 hectares, with a water surface of 8.6 hectares. It was established in the 32nd year of the Guangxu period of the Qing Dynasty (1906) and is the earliest zoo in China to open and exhibit the most types of animals. It houses over 500 species of 5,000 animals and over 500 species of 10,000 marine fish and marine life. It receives more than 6 million visitors from China and abroad each year and is one of the largest zoos in China, as well as one of the world's renowned zoos (Figure 3).



Figure 3 Beijing Zoo Tourist Guide Map

Data released by the Beijing Park Management Center shows that during the "May Day" holiday in 2023, the city-owned parks in Beijing welcomed a peak flow of visitors, with a total of 2.9537 million visitors, a year-on-year increase of 173.47%, and an increase of 21.03% compared to the same period in 2019 before the pandemic. Among them, the Summer Palace received 575,900 visitors, the Temple of Heaven received 517,800 visitors, and Beijing Zoo received 467,800 visitors, ranking in the top three in total visitor reception.

Therefore, Beijing Zoo must take certain measures to improve the queuing phenomenon at the entrance of the scenic spot (Figure 4).



Figure 4: Beijing Zoo Entrance and Exit Guide Map

From Figure 4: Beijing Zoo Entrance and Exit Guide Map, it can be seen that Beijing Zoo has a total of 5 gates, namely the South Gate, South Second Gate, Southwest Gate, Northwest Gate, and North Gate (Oceanarium Entrance) (Table 1).

Table 1 Comprehensive Analysis of the Current Situation of Each Entrance at Beijing Zoo

Entrance	South Second Gate	Southwest Gate	Northwest Gate	North Gate (Oceanarium Entrance)
Main Mode of Transportation	Public transportation is the majority, followed by private cars, bicycles, or walking	No direct subway within 500 meters	There is a waterway in front of the gate, occasionally boats pass by, mostly walking	Mainly by car, some visitors also use public transportation
Visitor Type	Usually parents with children and the elderly, also a significant number of individual visitors	Usually parents with children and the elderly, mostly surrounding residents	Mostly local residents for leisure walks, few tourists from other places	Mainly group tours, mostly parents with children and grandparents, also couples
Number of Channels and Turnstiles	4 wider channels for wheelchairs and strollers, 5 ordinary channels, 1 group channel	One channel for vehicle traffic and one small door for pedestrians	One small door with one turnstile inside	A total of 4 turnstiles, with a dedicated group ticket inspection entrance
Parking Lot	Yes, but parking congestion occurs when there are many people	The parking lot of the nearby Fangyuan Building is open to the public, no parking pressure	No parking lot found	The parking lot is relatively crowded, which can easily cause traffic jams
Visitor Volume	High	Low	Low	High
Field Scene				W. PARKER I

The team members' field investigation found that the South Gate is currently under construction and closed. The South Second Gate, which is close to the subway station and has convenient transportation, is currently the entrance with the most visitors [2].

#### **3** IMPROVEMENT PROCESS

The team members utilized Six Sigma for analysis, a management method aimed at improving process quality and efficiency within an organization. It emphasizes the improvement of various processes by reducing variability and defects.

The Six Sigma methodology typically includes five major steps, commonly known as DMAIC, which stands for "Define - Measure - Analyze – Improve - Control". This framework is the core of the Six Sigma approach.

#### 3.1 Define

We first clarified the scope, objectives, and key project details to better understand the background, scope, and significance of the problem, providing clear guidance and a foundation for the subsequent DMAIC process.

#### 3.1.1 Problem statement

Some visitors to Beijing Zoo have reported that the queue time exceeded their expected waiting time and the queue order was chaotic, affecting their visiting experience. This has become an increasingly prominent issue among various tourist attractions, necessitating measures for improvement.

#### 3.1.2 Project scope

Before project analysis, the scope of the project must be determined, including which aspects will be affected and the areas that need improvement. The scope of the project in this issue includes: waiting time in queues, queue lines and layout, staff allocation, and communication of queue information.

#### 3.1.3 Stakeholders and customers

Identify the stakeholders and customers of the project, including: visitors (customers), the tourist attraction management team, staff, and surrounding communities (which may be affected by the queue). This project can improve the queue situation, enhance customer experience and satisfaction, facilitate the management of the tourist attraction team, make the work of staff smoother, and reduce congestion in surrounding communities.

#### 3.1.4 Impact and importance of the problem

The actual impact of long queue times on the operation of tourist attractions and visitor experience may include: visitor loss, affecting the revenue of the attraction; visitor dissatisfaction, causing a negative impact on the reputation of the attraction; increased work pressure on staff, affecting the quality of service.

#### 3.2 Measure

In the second step, Measure, the team collects and records initial data related to the problem to establish a baseline for the issue. This is used to quantify the extent and impact of the "long queue waiting times at tourist attractions" problem.

#### 3.2.1 Data collection plan

Firstly, to assess the problem of long queue times, we identified the types of data needed, including: observing peak and off-peak visitor volumes, the distribution of visitor types, and the waiting time for visitors to enter the attraction.

#### 3.2.2 Data collection execution

Secondly, according to the data collection plan, we began to collect relevant data. The team conducted on-site field investigations at the main entrance (South Gate) of Beijing Zoo from 7:00 AM to 4:00 PM, collecting data every 25 minutes (data collection duration was 5 minutes) [3]. We obtained a series of related data, such as the time visitors spent entering the attraction, queue length, and waiting time, and conducted visitor satisfaction surveys to obtain feedback. The data we obtained is as follows:

(1) Time spent by visitors entering the attraction:

- ① 7:00-8:00, fewer visitors, smooth queues, approximately 2 minutes
- 2 8:00-9:00, increasing visitor numbers, slightly longer waiting times, approximately 4 minutes
- ③ 9:00-10:00, many visitors, long queues, increased waiting times, approximately 10 minutes
- ④ 10:00-11:00, slightly fewer visitors, approximately 8 minutes
- ⑤ 11:00-14:00, visitor numbers gradually decrease, from 8 minutes to around 5 minutes
- (6) 14:00-16:00, fewer visitors, smooth queues, approximately 2 minutes

#### (2) Visitor Satisfaction:

We randomly selected a total of 270 visitors and conducted a survey on their satisfaction with the queue waiting experience, with the following results (Figure 5):



Figure 5 Visitor Satisfaction Statistics

#### 3.2.3 Data analysis

The team members then analyzed the collected data to understand the severity of the queue time problem. We calculated the following metrics:

Average queue time is approximately 5 minutes

Visitor satisfaction is approximately 6.6

Satisfaction-related data (Figure 6):

effective	270
Missin	g 0
Mean	6.589
Median	7
Mode	7
Standard deviation	1.626
Variance	2.644
and	1779
	<b>D</b> 1 . 1 D .

Figure 6 Satisfaction-Related Data

#### 3.2.4 Data presentation

Present the analysis results in the form of charts, graphs, and reports to support further decision-making. After calculating the metrics, the team members created a line chart of the number of visitors to Beijing Zoo to show the trend of average queue times (Figure 7):



Figure 7 Line Chart of Visitors to Beijing Zoo

Through these steps, we obtained quantitative information about the problem of long queue times and provided strong support for the subsequent analysis and improvement steps in the DMAIC process [4].

#### 3.3 Analyze

Before analyzing, we reviewed the data collected in the second step, Measure, which included average queue times, visitor numbers, satisfaction scores, etc.

#### 3.3.1 Data visualization and exploration

We have visualized the above data using charts and graphs to better understand the distribution and trends of the data. *3.3.2 Possible cause analysis* 

We also conducted a cause-and-effect analysis of the long queue times at tourist attractions and created the following Ishikawa Diagram to identify possible causes of long queue times (Figure 8).


Figure 8 Ishikawa Diagram of Long Queue Times at Tourist Attractions

In Figure 8, we see that the problem of long queue times at tourist attractions is mainly caused by four major factors: visitor factors, process factors, facility factors, and personnel factors. These four factors contain many minor issues that together contribute to the congestion at tourist attractions. Therefore, we should address the issue of long queue times at Beijing Zoo from these four perspectives [5].

### 3.3.3 Main cause analysis

Based on the Ishikawa Diagram and the survey data, we created a fault tree analysis chart to explore the main reasons and solutions for the issue of queue times exceeding expected waiting times. Here is the chart we made (Figure 9).



Figure 9 Visitor Entry Process Flowchart for Beijing Zoo

According to Figure 9 and on-site observations, team members found that during the queue waiting process, there were people who ordered on-site while queuing, which affected the speed of the line; and when the queue changed from a single line to multiple channels, many visitors would leave the queue to take photos, which not only disrupted the order but also caused channel congestion; during ticket inspection, some visitors would encounter issues such as slow QR code loading and slow response from the turnstiles, leading to long ticket inspection times and slow queue movement.

We can conclude that "poor queue order" and "long ticket inspection times" are the two main reasons for queue times exceeding expected waiting times.

we denote the top event of long queue times at the attraction entrance as T, the intermediate event of poor queue order as M1, and the intermediate event of long ticket inspection times as M2. The basic events are visitors not following rules as X1, insufficient service staff capabilities as X2, slow response of ticket inspection machines as X3, and few ticket inspection channels as X4. Thus, we can deduce that:

$$T = M1 + M2 M1 = X1 + X2 M2 = X3 + X4$$
(1)

$$T = X1 + X2 + X3 + X4$$

Therefore, we can see that visitors not following rules, insufficient service staff capabilities, slow response of ticket inspection machines, and few ticket inspection channels are all minimal cut sets for the top event of long queue times at the attraction entrance. These four factors have a greater impact on queue times and are the most influential factors in causing queue times to exceed expected waiting times [6]. Hence, when addressing the issue of long queue times at the attraction entrance, we must not ignore these factors.

We now have a comprehensive understanding of the main causes of the problem of long queue times. This will provide a basic direction for the subsequent improvement measures, and we now move on to the next stage, Improve.

### 3.4 Improvement

Based on the data analysis results from previous steps, we have formulated the following improvement measures to address the issues identified in our analysis, utilizing methods such as queuing theory, category management, and visual management.

## 3.4.1 Solution identification

From the main cause analysis in step three, we have identified "visitors not following rules," "insufficient service staff capabilities," "long response times of ticket inspection machines," and "few ticket inspection channels" as the main factors. After discussion, the feasible solutions include the following:

(1) Based on our on-site observations, we found that even when some individuals had prepared their QR codes or ID cards in advance, they were still unable to pass through the turnstiles quickly, leading to increased queue waiting times and congestion, requiring additional manpower to resolve issues, which is a waste of resources.

After inquiring in detail with visitors who failed to scan their codes and the staff dealing with these issues, we discovered that the turnstiles could not read or verify the ticket provided by some visitors, which is the root cause of the problem.

Therefore, we decided to improve the turnstile system to address this issue [7]. First, we need to improve the information admission module of the turnstile to fill in the gaps where it could not previously admit some visitors' ID cards or QR code information. Secondly, we also need to improve the information verification module so that the turnstile can accurately recognize visitors ticket and quickly allow passage.

To achieve these improvements, we plan to take the following steps: First, technically upgrade the turnstile system to ensure it can read various types of IDs and QR codes. Second, we will establish a comprehensive database to store all legitimate visitors' identity information and ticket data, so that the turnstile can quickly verify and recognize them. At the same time, we will also strengthen the maintenance and monitoring of the turnstile system to ensure its stability and accuracy.

After these improvements, we believe that the turnstile system will be able to handle visitors ticket more efficiently and accurately, thereby reducing congestion and manpower waste, and enhancing the overall visitor experience.

(2) Through on-site observations, we found that Beijing Zoo has a serious congestion problem, especially during peak seasons and holidays. Visitors often gather in large numbers at the entrance in a short period, leading to excessive queue times and even congestion. This not only causes inconvenience to visitors but also affects the image and operational efficiency of the zoo. At many times, there are not many visitors gathering at the zoo entrance, and it is clear that there is a problem with this situation. We want to improve some functions to make the arrival time of visitors more even, thus solving the queue congestion problem.

To address this issue, we propose some improvement plans: Utilize Beijing Zoo's WeChat public account and mini-program to analyze data from entry and exit turnstiles, cameras, and visitor feedback to assess the density of visitor numbers in real-time and synchronize the results on the WeChat platform, allowing visitors to reasonably arrange their arrival and entry times to alleviate congestion. In addition, we can expand this plan to collect the density of visitors at different gates to provide a basis for visitors to choose the appropriate entrance. These improvement plans will effectively enhance the visitor experience and the operational efficiency of the zoo.

The common formula for calculating pedestrian flow is as follows:

(2)

Pedestrian flow = Area per person × Activity area × Activity frequency × Activity time

Area per person = Venue area

Activity area = Size of the activity area Activity frequency = Number of activities

Activity time = Duration of the activity

For the analysis of pedestrian flow in the queue at Beijing Zoo, we use cameras to record the total number of people in the venue and calculate the flow of visitors in a fixed area within a unit of time. The activity area is the total area provided for queuing at the entrance of Beijing Zoo, and the area per person is the activity area divided by the total number of people within a unit of time. The activity of opening the scenic area occurs once a day, and there are generally no other special activities affecting pedestrian flow, so it is not considered. The activity time is 20 minutes, and the data is updated every 20 minutes to show visitors the current flow of people and explain the flow situation (not congested, moderately congested, severely congested) to ensure that visitors understand the real-time data.

To implement the above improvement plans, we need to first establish a comprehensive data collection and analysis system, and at the same time, strengthen the interface with the WeChat platform to ensure the accuracy and timeliness of the information. At the same time, before promoting these functions, we also need to fully publicize to visitors, guide them to use the WeChat public account and mini-program, in order to further improve the coverage and practicality of this service [8].

We believe that through the above improvement plans, Beijing Zoo will be able to better meet visitor needs, enhance its image and operational efficiency, and lay a solid foundation for future sustainable development (Figure 10).



Figure 10 Location of Fangyuan Building, Southwest Gate, and Main Gate

(3) Due to the limited number of parking spaces in the zoo's parking lot and the large number of visitors traveling by car, there are always a large number of vehicles congested on the roadside near the zoo, waiting to enter the parking lot, causing interference with road traffic. To solve this problem, during our field investigation, we found that there are a large number of vacant parking spaces in the building near the southwest gate of Beijing Zoo, and the visitors entering from the southwest gate are basically nearby residents, so the number of visitors entering from the southwest gate is relatively small, which can alleviate the congestion problem at the south gate of Beijing Zoo (Figure 11).



Figure 11 Road Conditions at the Entrance of the South Gate Parking Lot and the Location Where Signs can be Placed

We can set up signs at the entrance of the parking lot and on the roadside, indicating that visitors should park in the parking lot ahead, reducing the queue time for vehicles. Moreover, the parking fee standard of Fangyuan Building is similar to that of Beijing Zoo, which will not bring too many additional costs to visitors. This is of great importance for alleviating road congestion.

(4) Based on our field investigation, we found that some families with infants and the elderly have difficulty traveling and need to bring strollers or wheelchairs when entering the park, which is slower than ordinary adults when queuing; in addition, scanning QR codes may be affected by temporary machine errors, dark phone screens, and other unexpected failures, affecting the progress of the entire queue. Moreover, during the waiting process, visitors may become anxious, affecting their travel experience.

Firstly, based on the relevant knowledge of queue psychology, our team has adopted a series of measures to reduce queue times and improve visitors' psychological experience. We guide visitor diversion and improve service efficiency to minimize queue times as much as possible. Secondly, we have added double-sided electronic exhibition boards in the middle of the two channels. These exhibition boards play exciting animal videos and knowledge about living habits, aiming to improve visitors' psychological experience and alleviate their anxiety. In this way, visitors can not only be entertained and gain knowledge during the queuing process but also enjoy a more comfortable and pleasant waiting environment.

Secondly, we have also used category management methods. During the improvement process, team members made new divisions of the queuing route: utilizing the space in front of the south gate, which is under maintenance, to plan a fast track for visitors with physical passes such as ID cards and annual cards to pass quickly, reducing the time wasted by mistakes, and also freeing up more space for regular channels for family visitors and others, improving the overall efficiency of visitor entry to the park (Figure 12).



Figure 12 Current queuing route at the South Second Gate of Beijing Zoo

Finally, we also use visual management methods, adding ticket purchase procedures next to the mini-program code to reduce the input of guidance personnel, and we will also increase signs at visitor diversion points to achieve more accurate diversion.

We will consider the comprehensive effect and feasibility, combine the actual situation and resource limitations, and comprehensively adopt the above measures to determine the best solution, so that the scenic area can better solve the problem of long queuing times and improve visitor satisfaction and experience.

(5) We use the knowledge of queuing theory to solve the problems that arise, queuing theory is a discipline that studies queuing phenomena using mathematical methods such as probability and statistics.

The multi-queue multi-server model is a complex model composed of multiple single-queue single-server models combined according to certain rules. This model mainly has the following two different situations:

Customers come to a service system independently, different service desks handle different types of business, and customers choose the corresponding service desk to queue according to their own business needs, that is, multiple queues and multiple service desks are arranged in parallel, such as queuing for meals in a canteen, there are multiple windows, each with a queue, and students choose the queue according to the food they need.

Customers come to a service system independently, different service desks handle the same type of business, and customers choose a shorter queue to wait for service, which is also multiple queues and multiple service desks arranged in parallel, such as queuing for checkout in a large supermarket, customers choose the checkout counter with fewer queues after selecting goods.

The processes in both situations are shown in the figure below (Figure 13):



Figure 13 Improved queuing route at the South Second Gate of Beijing Zoo

This paper considers a system with n service desks, equivalent to n queues, where different service desks may provide different or the same services. These are treated as multiple parallel single-server queues. The system is modeled as n independent queues: customers form n separate queues, do not switch queues midway, and there are no instances of queue-cutting, resulting in n independent single-queue single-server queuing models.

Although multi-queue multi-server models may differ in service types, their service rates are roughly the same. Therefore, studying the total number of customers in the system only requires examining the situation of a single queue. The large deviation result for the length of a single queue is given by

$$P(O \ge |q) \approx e^{-I(q)} \tag{3}$$

At time t, the probability that the queue length exceeds a certain value can be obtained from the above formula, thus the total number of customers in the multi-queue multi-server system at time t satisfies

$$\frac{Q^{m}}{P(\frac{m}{m} > q)() \approx e^{-I(q)}} \qquad (4)$$

This implies that the average number of people in the multi-queue multi-server system at time t does not significantly differ from the number of people in a single queue at time t.

This paper uses this model to simulate and optimize the Beijing Zoo, designing suitable strategies.

Simulation and Optimization:

Taking the south gate of the Beijing Zoo as an example, there are currently 12 channels and 8 turnstiles, with 4 channels designated for wheelchairs and strollers. This study excludes special designated channels. Through surveys and statistics, the following table shows the flow of people at the Beijing Zoo for each period (Table 2):

Table 2 Flow of P	eople at the Beijing Zoo for	Each Period
Period	Off-Peak	Peak

7: 00-8: 00	688	1856
8: 00-9: 00	2530	3573
9: 00-10: 00	1562	2571
10: 00-11: 00	1842	3289
11: 00-12: 00	1560	3064
12: 00-13: 00	1660	2550
13:00-14: 00	1275	1930
14: 00-15: 00	1130	1780
15: 00-16: 00	921	2064
16: 00-17: 00	529	1362
17:00-18:00	112	792

The data for the two periods represents the customer arrival rate in units of people per hour (Figure 14).



Figure 14 A line chart of the Beijing Zoo's Flow of People for Each Period.

The statistical characteristics of this data set are as follows (Table 3):

Table 3 Statistical Characteristics of the Flow of People at the Zoo for Each Period

Statistical Feature	Value
Mean	723
Standard Deviation	494.6787
Skewness	-0.1802249
Kurtosis	1.160637

Three common distributions were fitted to the data, and the best distribution was chosen based on different standard errors. The fitting results are shown in the table below (Table 4).

Table 4	ing Results Data Table	e
Fitting Distribution	Parameters	Standard Error

Fitting Distribution	Parameters	Standard Error
Poisson Distribution	723	5.48861
Normal Distribution	723	98.84697
	494.6787	69.89779
Negative Binomial Distribution	1.434907	0.3771129
	723	123.375

Although the standard error of the size parameter in the negative binomial distribution is the smallest at 0.377, the standard error of another parameter is as large as 123.375. Therefore, considering the overall fit, the Poisson distribution with a smaller standard error of 5.4886 indicates that the arrival process of visitors during off-peak hours approximates a Poisson distribution. Similarly, for peak hours, a Poisson distribution with different parameters is simulated.

Since the number of visitors varies greatly at different times, it is necessary to study different periods when considering the opening of windows. This paper selects the periods with the highest number of visitors during off-peak and peak hours for study, i.e., 8:00-9:00 for both off-peak and peak hours. The arrival rate during off-peak hours at 14:00-15:00 is 22.3 (people/min), approximately 3 visitors per 2 minutes per turnstile; during peak hours at 8:00-9:00, the arrival rate is 42.88 people/min, approximately 3 visitors per minute per turnstile.

Next, the service rate of the turnstiles or workers is studied. By observing the service time for 400 visitors entering the turnstiles, the following table is obtained (Table 5):

Turnstile Service Time (seconds)	Number of People
0~8	69
8~16	73
16~24	56
24~32	40
32~40	35
40~48	20
48~56	18
56~64	19
64~72	16
72~80	15
80~88	13

Table 5 Service Time Statistics for Visitors Entering Turnstiles

Turnstile Service Time (seconds)	Number of People
88 or more	26

Through literature review, it is found that the service time follows a negative exponential distribution with a parameter of u = 0.0307(people/second) = 1.842 (people/minute). Since the arrival rate of visitors during off-peak hours is 1.39 (people/minute), the service rate is higher than the arrival rate, and visitors will not form long queues; there may be idle turnstiles. During peak hours, the arrival rate per turnstile is 1.842 (people/minute), i.e., the service rate is less than the arrival rate, and queues will form over time. Using the theory shown in 3.3.1 (5), the number of channels to be opened  $\frac{1.842k}{1.842k}$ 

at the zoo during peak hours is determined. With the rate function I(q)=qln 2.68 and setting the maximum queue length to 30,  $P(Q>30)=e^{-3ln\frac{1.842k}{2.68}} < e^{-3}$  is obtained, and it is found that k > 1.6, i.e., K > 11.6, thus at least 12 turnstile channels are needed.

### 3.4.2 Continuous improvement and feedback:

Based on the data and feedback after implementation, continuous improvement is carried out to ensure that the improvements are sustained and can adapt to changing circumstances. If there are still issues in some areas, adjustments and optimizations are made in a timely manner.

### 3.4.3 Communication and change management

During the implementation process communication is carried out with employees and visitors to explain the purpose and expected effects of the improvements. Ensure they understand the new processes and changes. The following table analyzes the key points of communication that need to be conveyed to employees and visitors (Table 6).

Communica tion Object	Main Content
Employees	Organize meetings or training - Explain the purpose, significance, and expected effects of the improvements - Clearly explain the new processes and changes - Encourage employees to provide feedback and opinions
Visitors	Post improvement plans and changes on official websites, social media, etc Send emails or text messages to notify visitors in advance - Post promotional posters to explain the purpose and effects of the improvements - Provide information brochures or guides - Set up signs or signs to guide visitors to use new services or facilities

# Table 6 Key Points of Communication with Employees and Visitors

### 3.4.4 Expected results

### (1) FlexSim Simulation

FlexSim simulation models can visually observe the operation mode of queuing at the south gate of the Beijing Zoo. Based on the content of 3.4.1 (5) in this paper, FlexSim simulation is used to simulate the multi-queue multi-server model system. The specific 3D simulation interface is as follows (Figure 15):



Figure 15 3D Simulation Interface of Multi-Queue Multi-Server Model

The interarrival time of visitors follows an exponential distribution with a parameter of 2.8 seconds, and the service time of the ticket gates follows an exponential distribution with a parameter of 32.57 seconds. After arriving at Beijing Zoo, visitors line up to enter, dispersing into the shortest queue without switching queues midway. Due to the large number of ticket gates, the difference between single queue-single server models in parallel queue models is small, so it is reasonable to convert to 8 ticket gates.

To determine if the number of ticket gates is reasonable, we need to see if the customer waiting time in line is appropriate. There is a slight difference in the number of people queuing at different ticket gates. We are now looking at the change in the number of customers waiting in Queue 1 and Queue 8 over time (Figure 16).



Figure 16 Change in the Number of Waiting Customers in Queue 1 and Queue 8

Observing the above figure, the trend of the number of people in Queue 1 and Queue 8 over time is roughly the same, with the maximum number of people in line around 30, and both starting to gradually increase from 8:00, then gradually rising and slowly stabilizing.

The service system is just a process of averaging. If it is during a busy period, the interarrival time of visitors will shorten, and the waiting time will increase. To reduce the waiting time for visitors and alleviate the workload of service staff, the number of ticket gates needs to be increased.

After mathematical analysis, it is necessary to add 4 more ticket gates, as shown in the figure below (Figure 17):



## Figure 17 Simulation Diagram After Adding 4 Ticket Gates

The above figure shows the specific 3D simulation interface of the 12 queues in the zoo queue, that is, the entire system includes 12 queues and 12 ticket gates, with the customer arrival interval and average service time remaining unchanged. Next, we look at the change in the number of people queuing in Queue 1 and Queue 8 after adding 4 ticket gates, see the figure below (Figure 18):



Figure 18 Change in the Number of People Queuing in Queue 1 and Queue 8 After Adding 4 Ticket Gates

There is a slight difference in the change in queue length between Queue 1 and Queue 8. The maximum number of people in Queue 1 is 3, and the maximum number of people in Queue 8 is also 3, but the trend is basically the same, with the peak appearing around 8:48. From this, it can be seen that after adding 4 ticket gates, the queue length has become significantly shorter.

In addition to simulating the increase in the number of ticket gates, we also optimized each ticket gate based on the improvement concept in 3.4.1 (1). Due to the large number of ticket gates, the difference between single queue-single server models in parallel queue models is small, so it is reasonable to convert to 1 ticket gate. The comparison before and after the improvement is shown in the figure below (Figure 19):



Figure 19 Comparison Diagram Before and After Improvement

As shown in the above figure, after the conversion, the interarrival time of visitors before the improvement follows an exponential distribution with a parameter of 22.4 seconds, and the service time of the ticket gates still follows an exponential distribution with a parameter of 32.57 seconds. When some visitors need to pass through the ticket gate, and the ticket gate cannot recognize their admission vouchers, it will cause a stall, thereby extending the queue time. According to observations, the solution time for visitors due to the ticket gate's inability to recognize admission voucher information generally exceeds 150 seconds. Therefore, in the simulation, visitors who have been queuing for more than 150 seconds will enter the group of customers who cannot pass through the ticket gate, and those who have been queuing for no more than 150 seconds will enter the group of visitors who pass through smoothly. After the improvement, due to the supplementation of the ticket gate's admission information, the situation where the ticket gate cannot recognize the visitor's admission voucher information has been greatly reduced, thereby improving the queue progress. After mathematical analysis, the interarrival time of visitors in the simulation after the improvement still follows an exponential distribution with a parameter of 22.4 seconds, and the service time of the ticket gates still follows an exponential distribution with a parameter of 25 seconds.

After running the FlexSim simulation, we obtained the following chart data (Figure 20):

Number of customers Vs Time (before) Waiting route (III)	Bar chart of customer wait time (front)	Customer Wait Time chart (front)
	9933 0 20 40 60 80	923 0 26
Customer passage bar chart (front)	Customer Passage chart (front) Input/Output 107 64	
Number of customers vs. time (after)	Bar chart of customer wait time (back) Average length of stay 6741 0 20 40 60	Customer Wait Time chart (back)
Customer passage bar chart (back)	Customer Passage chart (back)	

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### Figure 20 Chart Data Obtained After Running FlexSim Simulation

As shown in the above figure, the first five charts (from left to right) are the relevant data of visitors passing through the ticket gates before the improvement, and the last five charts (from left to right) are the relevant data after the improvement. After comparison, it is observed that the number of people on the waiting route has relatively decreased, the customer waiting time has also decreased, and the number of customers who cannot pass through the ticket gates has also decreased. Therefore, it is concluded that after the improvement, the situation where the ticket gate cannot recognize the visitor's admission voucher information will be reduced.

(2) Distribution of Survey Questionnaires

We distributed survey questionnaires to collect visitors' satisfaction with different improvement measures and the expected queuing time, and processed the data to obtain the following results (Table 7):

measure	Queue time (minutes)	Satisfaction rating (out of 10)
Improve the gate system	4	8
Improve the queue path	3	9
Small program Improveme	nts 4	7
Allocate parking properly	5	7

## Table 7 Expected Results of Visitor Queuing Time and Satisfaction

Through the above steps, the improvement plan can be effectively implemented to solve the problem of long queuing times, and continuous monitoring and feedback are maintained during the implementation process. After completing the fourth step Improve, we will enter the last stage of DMAIC, that is, Control.

## **3.5 Control**

When using the fifth step Control to study the improvement of the current queuing situation at the scenic spot, it can ensure that the solution to the problem is maintained for a long time, and a control plan is formulated to monitor and manage the process.

### 3.5.1 Control plan development

We will develop a detailed control plan to ensure the continuous maintenance of the solution to the queuing time problem. After team discussion, the plan will include the following content (Table 8):

	Table 8 Control Plan and Content Explanation
Control Plan	Content Explanation
Measurement Indicators	Determine the key indicators that need to be monitored, such as average queuing time, visitor satisfaction, etc.
Data Collection Frequency	Determine the frequency of data collection, such as daily, weekly, or monthly.
Responsible Person	Appoint a person in charge of data collection and monitoring work.
Control Limits and	Set control limits and target values to take timely measures when the data exceeds the

Control Plan	Content Explanation
Targets	threshold.
Feedback Mechanism	Determine how to communicate the changes and results of the data to relevant stakeholders.
Corrective Actions	Define the corrective actions to be taken when the data exceeds the control limits.

# 3.5.2 Data collection and monitoring

After the plan is determined, we will implement the identified improvement measures and establish a monitoring mechanism to monitor their impact, and verify the effectiveness of the improvement after a period of time. Continue to collect feedback and data, compare the queuing time and visitor satisfaction before and after the improvement, and other indicators to ensure the accuracy and consistency of the data and that the improvement measures meet the original goals.

# 3.5.3 Implementation of statistical process control

In the statistical process, set key performance indicators such as average queuing time and visitor satisfaction, and conduct continuous monitoring. Use statistical process control (SPC) tools, such as control charts, to analyze and monitor the data. Control charts can help detect any abnormalities or trends in a timely manner, so that necessary measures can be taken in a timely manner.

# 3.5.4 Performance review and reporting

Regularly review the data and compare it with the control limits and targets. Report the project results to the scenic spot management and other stakeholders based on the data, and create reports to show the results of the improvement and the status of the problem.

# 3.5.5 Continuous improvement and adaptation

Based on the monitoring results, we regularly evaluate the queuing time and make necessary adjustments and improvements according to the obtained queuing time. If the data shows that the problem reoccurs or exceeds the control limits, take immediate corrective actions for continuous improvement and adaptation to achieve a long-term solution and continuous improvement of the queuing problem at the scenic spot entrance.

# 3.5.6 Training and communication

Train staff to understand and be able to implement the new queuing process, ensuring that all employees understand the control plan, know how to collect data, and understand its importance. At the same time, team members should maintain communication with employees and relevant departments to ensure that the scenic spot management team provides key support and resources. Ensure the smooth progress of the project.

After completing the fifth step Control, we can ensure that the solution to the queuing time problem is sustained, thereby achieving long-term improvement effects and laying the foundation for continuous improvement and management.

Through the implementation of the above plan, we anticipate that we can effectively reduce the waiting time for visitors in queues, enhance the visitor experience, reduce the rate of visitor loss, and increase the retention rate of visitors. At the same time, optimized queue management will alleviate the work pressure on management staff, improve the efficiency of resource utilization at the scenic spot, and increase the economic benefits and reputation of the scenic spot. The successful implementation of the project will provide an innovative example for solving queuing problems at scenic spots and also provide valuable experience for the application of industrial engineering and lean management in the tourism industry.

# 4 Summary and Outlook

With the recovery of the tourism economy and the expectation of continued steady growth in domestic tourism in the coming years, we have identified the issue of queuing at tourist attractions as a significant factor affecting visitors' experience. We have managed this queuing problem using queuing theory, stratification, and other industrial engineering and lean management methods, which holds positive significance and plays an essential role. The implementation of these industrial engineering and lean management methods can improve the management efficiency of tourist attractions, reduce costs, enhance competitiveness and innovation capabilities, and promote the sustainable development of the tourism industry. At the same time, it can also promote the improvement of service quality and human resource management in tourist attractions, making a positive contribution to the development of the cultural and tourism industry.

# **COMPETING INTERESTS**

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

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# THE CONSTRUCTION OF "GOLDEN COURSES" FOR UNIVERSITY HEALTH MANAGEMENT IN THE ERA OF ARTIFICIAL INTELLIGENCE

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Abstract: In response to the call for constructing national first-class undergraduate courses and promoting educational reform, this study explores new pathways for artificial intelligence (AI) to assist in the development of "golden courses" in university health management, aiming to provide a reference for improving the current state of health education in universities. Through a literature review, the importance of constructing "golden courses" for university students' health management is recognized, along with issues such as outdated teaching content, obsolete teaching methods, and insufficient student engagement. Therefore, this study applies an interdisciplinary research approach to integrate AI technologies with university health management education, aiming to innovate teaching methods and improve teaching quality. Ultimately, an AI-assisted construction plan for health management "golden courses" is developed, encompassing the entire teaching process. This plan helps address the shortcomings of traditional health management courses, enhances teaching quality, and facilitates the transformation of educational outcomes, enabling students to acquire knowledge and skills for self-health management, thereby improving the overall health level of university students.

Keywords: University health management; "Golden course" development; Artificial intelligence

# **1 INTRODUCTION**

In August 2018, the Ministry of Education issued the "Notice on the Implementation of the Spirit of the National Conference on Undergraduate Education in the New Era" (Jiao Gao Han [2018] No. 8), proposing that "universities should comprehensively review the teaching content of all courses, eliminate 'low-quality courses,' and create 'golden courses". Significant achievements have been made in the construction of "golden courses," with academic exploration in this area becoming increasingly mature, particularly in ideological and political education [1], medical practice [2], and other professional courses. With the introduction of the "Healthy China" strategy, individuals' awareness of actively promoting their health has increased, along with a stronger desire for self-health management [3]. Given the inadequacies of traditional health education in universities, the unsatisfactory outcomes of health education, and the inability to meet the diverse health needs of university students [4], it is necessary to improve the content and methods of health education. As artificial intelligence (AI) has made significant contributions to societal and industrial development, the concept of "AI+Education" has emerged. For example, virtual simulation technology has been shown to significantly enhance teaching effectiveness in experimental teaching [5], and applying ChatGPT (Chat Generative Pre-trained Transformer) in medical consultation training for medical students can improve their learning outcomes and teaching quality [6]. However, there is limited research on using AI to advance the construction of "golden courses" in health management. Leveraging AI technology can promote the development of "golden courses" in health management, enrich health management content, improve teaching methods, and enhance teaching outcomes and course quality.

# **2** THE CORE SIGNIFICANCE OF CONSTRUCTING "GOLDEN COURSES" IN HEALTH MANAGEMENT AT UNIVERSITIES

While universities undertake the fundamental task of fostering moral character and cultivating talent, they must also emphasize the comprehensive development of students. Due to significant academic pressures and the influence of mass media and popular trends, university students face numerous health risks in their daily lives, which may even lead to adverse health outcomes [7]. Such situations pose a severe threat to the quality of future human resources and hinder the realization of the "Healthy China" objectives. Therefore, universities should actively promote the construction of "golden courses" in health management to enhance students' health management capabilities. This initiative not only improves students' own health and academic performance but also equips them to provide health guidance to their families and peers.

# 2.1 Constructing Targeted, Interactive, Innovative, and Practical Health Management Courses

Universities often focus on developing high-quality professional courses to enhance students' academic performance but neglect the cultivation of students' health management capabilities, with insufficient investment in health management-related faculty, funding, and equipment. Most students do not prioritize health management, believing that health management courses are unrelated to their academic studies, resulting in low enthusiasm for learning such

courses. Furthermore, the courses themselves have significant issues: the content of health management courses is often outdated and lacks novelty, teaching methods are overly simplistic, and the courses fail to attract students. The health management courses students receive are primarily limited to knowledge delivery, lacking practical application and innovation, and failing to effectively align with students' health needs. The course content does not integrate elements that interest students, such as weight loss, muscle building, dietary therapy, hair loss prevention, or skincare. Teaching methods predominantly rely on traditional lectures, with little interaction between teachers and students. The conventional teaching model restricts the dynamics of the classroom, as both teachers and students are confined to outdated teaching aids. Teachers struggle to present engaging content, while students face dull text and images, making it difficult for them to form a deep understanding and cognition of knowledge. This situation hinders the development of students' health management skills and literacy. Moreover, the "score-oriented" approach remains a persistent issue in traditional Chinese education. Although course evaluation methods have evolved to include attendance, class participation, and exam scores as a weighted average for final grades, this formative assessment method is relatively crude, making it difficult to monitor students' learning progress in real time, which is not conducive to providing tailored guidance. Therefore, university health management courses should be tailored to the needs of college students, incorporating targeted, interactive, innovative, and practical elements.

# 2.2 Adopting Diverse Teaching Methods to Develop Health Management Courses

Artificial intelligence (AI) has now deeply integrated into various sectors of society, such as healthcare [8], public health [9], and education [10]. With the development of AI, its relationship with health promotion and protection has become increasingly close, enabling the realization of personalized prevention [11]. AI-based educational solutions are becoming increasingly mature [12], and AI holds great promise in addressing the gaps in learning and teaching needs. The intelligentization of health management in universities is an inevitable trend, necessitating the exploration of practical pathways for AI-assisted health management course development. Artificial intelligence refers to the process by which computers and machines simulate human behaviors, including perception, learning, reasoning, analysis, and decision-making, through data processing and pattern recognition [12]. The five main subfields of AI include machine learning, deep learning, neural networks, computer vision, and robotics. In view of the current inadequacies in health education at universities, this paper will leverage artificial intelligence to explore practical pathways for the intelligentization of health management courses in higher education institutions.

# **3** UNIVERSITY HEALTH MANAGEMENT "GOLDEN COURSE" DEVELOPMENT SUPPORTED BY ARTIFICIAL INTELLIGENCE

# 3.1 Multimodal Analysis in Artificial Intelligence

Multimodal analysis refers to a technology that uses sensing devices and computer systems to analyze and process information such as text, behavioral data, and videos. This technology enables teachers to gain a basic understanding of students' behavioral lifestyles and health management capabilities before class, thereby facilitating tailored health management course instruction. By analyzing students' behavioral habits, interests, preferences, and psychological dynamics, each student is assigned a personalized label. This information is then transmitted to the teacher, allowing them to gain timely insights into each student's situation and develop a personalized health management course learning plan for them [13], effectively addressing students' actual learning needs. This approach can efficiently solve the information asymmetry issues inherent in traditional teaching methods and provides an innovative form of instruction.

# **3.2 Algorithm Recommendation**

Algorithm recommendation refers to a series of activities that use mainstream machine learning algorithms to build data models, track user data, analyze user behavior, and predict user needs, thereby pushing relevant content to users. Currently, many applications (APPs) adopt this approach to closely align with user preferences, enhancing user "stickiness" to the APP. As an online education platform, China's MOOC (Massive Open Online Courses) provides students with access to a wide range of high-quality university courses, allowing them to select courses of interest as supplementary learning resources for health management. Compared with algorithm recommendation, ChatGPT, as a natural language processing technology, can automatically process and generate natural language, offering personalized services for university students by answering their questions about health management and providing guidance. Therefore, integrating algorithm recommendation and ChatGPT into university health education can meet students' individualized health management needs, enhance the online learning experience, and improve the overall effectiveness of course learning.

# 3.3 VR (Virtual Reality) + Classroom Practice

Virtual simulation technology, based on digitalization and simulation technologies, creates a virtual space that simulates realistic social scenarios, enabling individuals to independently perceive and experience these environments, thereby achieving a "fusion" between individuals and their surroundings. Artificial intelligence-powered virtual simulation

technology can construct immersive three-dimensional multisensory environments, creating a learning space where reality and virtuality intertwine, making interactive, cross-temporal, and cross-spatial education a reality [14]. Limited by factors such as space, experimental equipment, and consumables, many health management practice courses are conducted merely by watching videos and courseware, resulting in poor teaching outcomes. Virtual simulation-based experimental teaching provides students with a vivid, realistic, visual, and highly interactive learning and experimental environment, which can optimize classroom experiences and improve the effectiveness of practical courses [15]. Virtual simulation technology serves as a bridge to overcome traditional teaching barriers, ensuring the enhancement of offline teaching outcomes and supporting the implementation of health management practice training courses.

### 3.4 Intelligent Association in Artificial Intelligence

Intelligent association is not a specific artificial intelligence technology but rather a concept enabled by a range of core AI technologies, including natural language processing, machine learning, and intelligent mining technologies [14]. It facilitates the formation of connections between objects, effectively integrating formative and summative evaluations, allowing teachers to dynamically monitor the entire teaching process and aiding in the construction of a smart campus. Through the smart campus platform, teachers can provide students with learning guidance, evaluation, and intervention. This platform-based approach helps bridge the gap between teachers and students, streamlines communication channels, and enables timely interventions to care for and support each student, contributing to educational equity [16]. Additionally, the platform can be used to compare changes in students' health behaviors before and after participating in health management courses, providing auxiliary evaluation of teaching quality. The teaching model of health management "golden courses" based on artificial intelligence explored in this study is illustrated in Figure 1.



Figure 1 Flow Diagram of a Teaching Model Based on Artificial Intelligence

# 4 ADVANCEMENT STRATEGIES FOR BUILDING "GOLDEN COURSES" IN UNIVERSITY HEALTH MANAGEMENT

### 4.1 Goals for Constructing "Golden Courses" in University Health Management

From the perspective of course objectives, constructing personalized, interactive, innovative, and practical high-quality courses requires attention to the entire teaching process. The primary focus of teaching is on students, who are the central participants in the classroom; therefore, it is essential to fully engage students and meet their personalized needs. The teaching content serves as the source of students' learning, so it must be rich, integrate multidisciplinary knowledge, include high-quality materials, and be innovatively optimized by incorporating students' interests and societal trends. The teaching environment, or teaching scenario, encompasses online teaching, offline teaching, and blended learning that combines both. Offline teaching is constrained by space and time, limiting its potential effectiveness, while online

teaching requires a high level of student self-discipline [17]. Therefore, a blended teaching approach combining online and offline methods can enhance learning outcomes [18]. Teaching evaluation should adopt a diversified approach, balancing formative and summative assessments, and focus on transforming students' acquired knowledge into skills and competencies.

### 4.2 Practical Pathways for Building "Golden Courses" in University Health Management

### 4.2.1 Enhancing awareness of "Golden Courses" among relevant atakeholders

Enhancing awareness of "golden courses" requires targeted promotion and education for relevant stakeholders [19]. First, teachers and students, as the most direct participants and key contributors to the development of health management "golden courses," play a critical role. Teachers should cultivate a sense of responsibility for building high-quality health management "golden courses," improve course quality, incorporate contemporary features, innovate course design, encourage active student engagement, and ultimately help students develop health management skills and literacy. Second, universities can use campus broadcasting stations, official WeChat accounts, Douyin (TikTok), and other social media platforms to promote health management courses among students, increasing their interest in the subject. Third, universities should emphasize the importance of health management "golden courses," and supporting research efforts by faculty and students on university health management courses. These research findings can then guide the development of health management "golden courses," Finally, the purpose of health management "golden courses" extends beyond imparting knowledge; it focuses on enhancing health management skills and literacy, promoting healthy behaviors and lifestyles among students, and fostering a positive influence on the people around them.

## 4.2.2 Improving teaching facilities for health management courses

Leveraging advanced teaching tools such as artificial intelligence multimodal analysis, algorithm recommendation, ChatGPT, VR, intelligent association, smart wearable devices, and smart classrooms can enhance the overall teaching effectiveness of health management courses. These tools not only improve instructional quality but also provide strong support for skill training in practical courses, allowing students to engage in immersive training for disease management and health promotion techniques. Additionally, it is essential to provide training for teachers to enhance their comprehensive capabilities, foster a sense of course innovation, and enable them to master advanced teaching tools proficiently [20]. By utilizing these cutting-edge tools, universities can improve students' classroom experience and initiative, fully empower them as active participants in their learning process, and cultivate a sense of proactive practice both in the classroom and in daily life.

# 4.2.3 Defining standards for university health management "Golden Courses"

In November 2018, the "Building China's Golden Courses" report proposed the "Two Characteristics and One Degree" standard for "golden courses," emphasizing advancedness, innovativeness, and challenge [21]. This standard is equally applicable to the development of health management courses. Advancedness focuses on the comprehensive cultivation of students' health management knowledge, skills, and literacy. Teachers should highlight the importance of developing students' health management abilities and literacy in their teaching objectives and actively stimulate students' autonomy during the learning process. The content of health management courses should align with cutting-edge requirements in contemporary health management, be continuously refined based on students' interests, and incorporate innovative approaches to enhance content quality and novelty while promoting active student interaction during lessons. Students should apply health management knowledge and skills to reflect on their own health status, independently explore learning opportunities, and engage in health management activities outside the classroom to improve their overall well-being. Challenge refers to the inclusion of not only basic health management concepts but also more technically demanding knowledge within the course. This ensures that students are encouraged to tackle advanced problems, which can only be mastered through dedicated effort, thereby inspiring enthusiasm for learning health management knowledge and participating in health management knowledge.

# 4.2.4 Constructing a curriculum system for health management "Golden Courses"

In line with the requirements for "golden course" development, efforts should focus on five aspects: teaching objectives, content, methods, tools, and evaluation. The teaching objective should aim to cultivate students' health management skills and literacy, enabling them, through course learning, to identify health risk factors, carry out corresponding health promotion activities, or provide health guidance to others [22]. In terms of course content, the curriculum should be enriched with engaging and illustrative case studies and virtual simulation scenarios. Beyond basic health management knowledge, the curriculum should incorporate practical teaching segments such as chronic disease management and training in health promotion skills. Additionally, teaching methods should be adapted to the characteristics of university students, utilizing diverse approaches that emphasize classroom interaction and encourage student participation. Teaching tools are essential for conducting educational activities; leveraging artificial intelligence teaching technologies can enhance the effectiveness of health management courses and foster students' full engagement in the learning process. Consequently, teachers should receive training in teaching tools to enable them to proficiently use AI teaching technologies, thereby improving their professional competencies. Course evaluation is crucial for summarizing course outcomes and improving course quality. Smart campus platforms and AI-driven intelligent association technologies can facilitate mutual evaluations between teachers and students, enhancing teaching outcomes. Teachers can use backend data to assess students' learning outcomes and provide targeted guidance and interventions, while students can evaluate

teachers' teaching effectiveness, give ratings, and propose suggestions for course improvement, fostering mutual growth in the teaching-learning process.

# 4 CONCLUSION

Exploring the research and practice of university health management "golden courses" in the context of artificial intelligence aligns better with the requirements of educational reform and meets students' needs for health promotion. The construction of health management "golden courses" in universities enhances the effectiveness of health education, adapts to the trends of proactive health in the current era, and represents a significant initiative toward realizing the "Healthy China" vision. Furthermore, it is essential to make rational use of AI technologies such as multimodal analysis, algorithm recommendation, ChatGPT, VR, and intelligent association while safeguarding students' personal privacy and addressing the ethical issues arising from the application of artificial intelligence.

# **COMPETING INTERESTS**

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

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# HARNESSING THE TRANSFORMATIVE POTENTIAL OF THE DIGITAL ECONOMY FOR HIGH-QUALITY GROWTH: EVIDENCE FROM CHINA

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**Abstract:** This study investigates the impact of the digital economy on new quality productivity in China from a machine learning perspective. Employing panel data from 30 Chinese provinces spanning 2012-2021, the research utilizes various econometric and machine learning techniques, including fixed effects models, generalized method of moments, random forest, mediation analysis, and threshold regression. The findings reveal a robust positive relationship between digital economy development and new quality productivity, with green innovation playing a crucial mediating role. The random forest model uncovers a nonlinear relationship, where the marginal contribution of the digital economy to productivity exhibits an inverted U-shaped pattern. Furthermore, the threshold regression analysis highlights the moderating effect of innovation, with the productivity-enhancing impact of the digital economy amplified at higher levels of innovation. These results underscore the transformative potential of digital technologies in driving high-quality economic growth, while emphasizing the importance of fostering green innovation and an enabling innovation ecosystem. The study offers valuable insights for policymakers, advocating for a holistic, innovation-centric approach to harnessing the digital economy as a catalyst for sustainable development.

Keywords: Digital economy; New quality productivity; Green innovation; Machine learning; Threshold effect

# **1 INTRODUCTION**

The advent of the digital era has brought about profound changes in the global economic landscape. The accelerated integration of digital technologies, such as big data, cloud computing, artificial intelligence, and blockchain, with the real economy has become a key driving force for high-quality economic development [1]. As a new economic form, the digital economy is not only reshaping traditional industries but also fostering the emergence of new industries and business models, thereby injecting new vitality into economic growth [2]. The digital economy has become an important engine for promoting total factor productivity and cultivating new drivers of economic development [3].

In the context of the rapid development of the digital economy, the connotation of productivity has also undergone profound changes. The traditional productivity concept, which mainly focuses on the efficiency of factor inputs, can no longer fully adapt to the new requirements of high-quality economic development in the digital era [4]. The concept of new quality productivity, which emphasizes innovation-driven, green and low-carbon, and inclusive growth, has become a new benchmark for measuring a country's comprehensive competitiveness [5]. The deep integration of digital technologies with traditional industries can help improve production efficiency, upgrade product quality, and promote the green and intelligent transformation of industries, thereby contributing to the cultivation of new quality productivity [6].

However, the existing research on the relationship between the digital economy and new quality productivity still faces some limitations. On the one hand, most studies focus on the impact of a single dimension of the digital economy, such as e-commerce [7], digital finance [8], and digital inclusion [9], lacking a comprehensive evaluation of the development level of the digital economy from multiple dimensions. This makes it difficult to fully capture the overall impact of the digital econometric methods, such as regression analysis and panel data models, which have limitations in dealing with complex nonlinear relationships and high-dimensional data [10]. Machine learning methods, such as random forest and neural networks, have unique advantages in capturing complex relationships and identifying key influencing factors [11], but there is still a lack of relevant research in the field of digital economy and new quality productivity.

To bridge these research gaps, this paper takes 30 provinces in China (excluding Tibet) from 2012-2021 as the research sample, and constructs a comprehensive evaluation index system to measure the development level of the digital economy and new quality productivity using the entropy weight method. The research adopts a variety of machine learning methods, including the double fixed effect model, generalized moment estimation, random forest model, and threshold model, to empirically examine the impact of the digital economy on new quality productivity and its boundary conditions. Specifically, the random forest model is employed to explore the nonlinear relationship between the digital economy and new quality productivity and to identify the key influencing factors. The random forest model integrates multiple decision trees through bagging and random feature selection, which can effectively improve the accuracy and robustness of the model [12]. Moreover, this paper investigates the mediating effect of green innovation and the moderating effect of innovation level on the relationship between the digital economy and new quality productivity, aiming to reveal the internal mechanism and boundary conditions of the digital economy's impact on new quality productivity.

The main contributions of this study are as follows. First, it constructs a multi-dimensional comprehensive evaluation framework for measuring the development level of the digital economy and new quality productivity, providing a new

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perspective for quantitative research in this field. Second, the application of machine learning methods, especially the random forest model, helps to capture the complex nonlinear relationship between the digital economy and new quality productivity and to identify the key influencing factors, deepening the understanding of the mechanism of the digital economy's impact on new quality productivity. Third, by examining the mediating effect of green innovation and the moderating effect of innovation level, this paper reveals the realization path and boundary conditions of the digital economy's impact on new quality productivity, providing valuable insights for formulating targeted policies to promote high-quality economic development in the digital era.

The remainder of this paper proceeds as follows. Section 2 presents the theoretical analysis and research hypotheses. Section 3 describes the research design, including the model specification, variable measurement, and data sources. Section 4 reports the empirical results and discusses the findings. Section 5 concludes the paper and offers policy implications.

### 2 RESEARCH DESIGN AND DATA SOURCES

### 2.1 Modeling

To systematically examine the impact of digital economy development on new quality productivity, this study employs multiple econometric models for empirical analysis, including the fixed effects model, Generalized Method of Moments (GMM), mediating effects model, random forest model, and threshold effect model. The rationale for using multiple models is twofold. First, different models have respective strengths in dealing with panel data and endogeneity issues, and combining them helps unveil the relationship between the digital economy and new quality productivity from various angles, aiming to obtain robust conclusions. Second, the relationship between the digital economy and new quality productivity is complex, and traditional linear models may not fully capture its heterogeneity and nonlinearity. Introducing machine learning models like the random forest can help uncover more valuable information.

### 2.1.1 Fixed effects model

Considering the potential province-level and time-level inherent differences between digital economy development and new quality productivity, traditional pooled OLS regression may be biased. Therefore, we first employ the fixed effects model to control for such unobservable heterogeneity. The model is specified as follows:

$$Np_{it} = \beta_0 + \beta_1 Dig_{it} + \sum \beta_2 control_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$
(1)

where  $Np_{it}$  represents the new quality productivity level of province i in year t;  $Dig_{it}$  represents the digital economy development level of province i in year t; *control*<sub>it</sub> includes a series of control variables: the level of openness (open), environmental regulation (ec), industrial structure (ls), innovation level (lninv), and technological marketization level (tm);  $\mu_{i}$  is the province fixed effect, controlling for time-invariant heterogeneity across provinces;  $\lambda_t$  is the time fixed

effect, controlling for common shocks faced by all provinces; and  $\varepsilon_{it}$  is the random error term.

The fixed effects model introduces dummy variables  $\mu_{i}$  and  $\lambda_{t}$  to decompose the dependent variable  $Np_{it}$  into three

parts: individual differences, time differences, and random disturbances. This approach can alleviate endogeneity issues caused by omitted variables to a certain extent. However, it assumes that the omitted variables are uncorrelated with other explanatory variables, which is often hard to satisfy in practice. Moreover, the fixed effects model can hardly identify the dynamic effects of key variables and is powerless for nonlinear relationships.

## 2.1.2 GMM model

To further mitigate endogeneity and examine the dynamic effects of variables, this study introduces the Generalized Method of Moments (GMM) based on the fixed effects model, adopting both the system GMM and the difference GMM:

$$Np_{it} = \beta_0 + \beta_1 Np_{it-1} + \beta_2 Dig + \sum \beta_3 control_{it} + \varepsilon_{it}$$
<sup>(2)</sup>

In view of the limitations of short panel data and the risk of endogeneity, this paper chooses the generalized moment estimation method, the best method at this time is the generalized moment estimation, which mainly includes the systematic moment estimation and differential moment estimation, so this paper uses the systematic GMM method and differential GMM.

### 2.1.3 Mediating effects model

To reveal the transmission mechanism through which the digital economy affects new quality productivity, this study further examines the mediating effect of green innovation. The mediation effect testing procedure proposed by Baron and Kenny (1986) requires estimating the following equations:

$$\ln gn_{it} = \beta_0 + \beta_1 Dig_{it} + \sum \beta_2 control_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$
(3)

$$Np_{it} = \beta_0 + \beta_1 \ln gn_{it} + \beta_2 Dig_{it} + \sum \beta_3 control_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$
<sup>(4)</sup>

Among them,  $\ln gn_{it}$  is the mediating variable, including green patent applications  $\ln gt_{it}$ , green utility model applications  $\ln gu_{it}$  and green invention patent applications  $\ln gi_{it}$ . It should be noted that the mediating effect model cannot identify the causal mechanism between variables from the perspective of causal inference, and there may be omitted variable bias between the mediating variable and the dependent variable. Therefore, caution is needed when interpreting the mediating effect.

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### 2.1.4 Random forest model

The above models are based on linear assumptions and cannot examine the potential nonlinear relationships between variables. Therefore, this study further employs the random forest model, a bagging ensemble learning method based on decision trees, to explore the nonlinear impact of the digital economy on new quality productivity. By comprehensively training and predicting sample data with multiple decision trees, this model can effectively capture and utilize the data information of each variable, accurately assess the nonlinear relationship between variables, and more closely match the complex associations in the real world. This allows us to quantitatively compare the contribution of the digital economy to new quality productivity relative to other influencing factors. The specific model is set as follows:

$$Np_{ii} = \emptyset(X_{ii}, controls_{ii}, \mu_i, \varepsilon_{ii})$$
(5)

Among them,  $X_{ii}$  is the core explanatory variable digital economic development level, and  $\emptyset(.)$  is the nonlinear model constructed under the random forest method.

The random forest model, as a black-box function with no expression and no tree diagram output, can be used to generate a scatter plot of the bias function f(xs) of the independent variable xs versus xs with the help of the R language to visualize the marginal impact of the digital economy on the new quality productivity. In this process, f(xs), as the bias function of xs, is treated as a marginal effect of other variables  $xm^{(i)}$  by controlling their actual values to remain unchanged, so that f(xs) is only related to the independent variable xs and its interaction term with other variables. To obtain the value of the bias function, we can train several classifier models in parallel on the original data, and then average the outputs of all models to obtain:

$$f_{xs}(xs) = \frac{1}{n} \sum_{i=1}^{n} f(xs, xm^{(i)})$$
(6)

where  $xm^{(i)}$  represents the value of variables other than xs at the ith sample point. By examining the changing trend of the bias function f(xs) with respect to xs, we can intuitively understand the marginal effect of the digital economy development level on new quality productivity and its changing characteristics.

### 2.1.5 Threshold effect model

According to the theoretical analysis in the previous section, the impact of digital economy development on new quality productivity may exhibit a nonlinear relationship. To test this research hypothesis, this study adopts the threshold regression model with innovation level as the threshold variable to explore the threshold effect of digital economy development on new quality productivity. The model is specified as follows:

$$Np_{it} = \beta_0 + \beta_1 \ln gn_{it} \times I(Dig_{it} \le \gamma_1) + \beta_2 \ln gn_{it} \times I(Dig_{it} > \gamma_1) + \sum \beta_{\xi} ontrol_{it} + \varepsilon_{it}$$
(7)

where Th\_{it} is the threshold variable, innovation level, including three indicators: green patent applications (lngt), green utility model applications (lngu), and green invention patent applications (lngi); I(\*) is the indicator function, taking the value of 1 when the condition inside the parentheses holds, and 0 otherwise; and  $\gamma$  is the threshold value to be estimated. Equation (7) allows the regression coefficient of digital economy development to exhibit a stepwise change under different innovation level regimes. If the threshold effect is significant, it indicates that the relationship between digital economy development and new quality productivity will undergo structural changes as the innovation level increases. We employ the bootstrap method to test the significance of the threshold effect and determine the confidence interval of the threshold estimate through grid search, aiming to comprehensively characterize the nonlinear impact of digital economy development on new quality productivity.

### 2.2 Selection of Variables

#### 2.2.1 Explained variables

New quality productivity (Np), from the three aspects of workers, labor objects, and means of production, using entropy weight method to construct the new quality productivity indicator system, specific measurements as shown in Table 1.

Level 1	Secondary	Tertiary	Indicator measurement	Indicator
indicators	indicators	indicators		properties
labor force	Worker	labor force level	Level of education per capita	+
	SKIIIS		Human capital structure	+
		Per capita output	GDP per capita	+
		Wages per capita	Average wages on board	+
	Productivity levels	employment level	Share of employees in the three industries	+
4		Entrepreneurship level	Entrepreneurial activity	+
target audience	· 1 /	emerging industry	Share of emerging strategic industries	+
	new industry	high and new technology	Number of robots	+
	ecological	Green development	forest cover	+

	environment	pollution	Share of environmental expenditures	+
		prevention and	Pollutant emissions	-
		control	control of pollution sources	+
			Road mileage	+
		:	Railroad mileage	+
r infor means of production	material information	mirastructure	Fiber Length	+
			Internet access per capita	+
		anarmi	energy consumption	-
		consumption	Renewable energy consumption	+
		technological	Patents per capita	+
	Intangible	innovation	R&D investment	+
	information	Level of	Digital Economy Index	+
		digitization	Enterprise digitization level	+

### 2.2.2 Explanatory variables

Digital economy level (Dig), using entropy weight method to establish an evaluation model, quantitatively evaluating the level of digital economy development through the four dimensions of digital carriers, digital industries, industry level and digital environment, the detailed measurements are shown in Table 2.

Level 1 indicators	Secondary indicators	Indicator measurement	Indicator properties
		Internet Broadband Access	+
		Internet broadband access	+
1 1 .	Informatization	Number of domain names	+
digital carrier	scale	Number of pages	+
		Long-haul fiber optic cable length	+
		cell phone base station	+
		Total assets of the electronic	
	1 / 1	information manufacturing industry	+
	electronic	Number of enterprises in the	
	information industry	electronic information manufacturing	+
		industry	
digital		Total telecommunication services	+
industry		Revenue from software products	+
	Software and	Number of software developers	+
	information technology	Embedded systems revenue	+
	services	Number of high-tech listed	
		companies	+
		Value added of agriculture,	
	Digitization of	forestry, livestock and fisheries	+
	agriculture	Rural electricity consumption	+
		Computers per 100 persons in	
		industrial enterprises	+
industrial	Industrial	High-tech main business income	+
level	digitization	Patent situation in high-tech	
		industries	+
		Share of e-commerce trading	
	Digitization of the	companies	+
	service sector	E-commerce sales	+
		Digital Inclusive Finance Index	+
		Number of general colleges and	
	Intellectual capital	universities	+
digital	environment	Expenditure on education	+
environment	<b></b>	R&D project funding	+
	Digital innovation	Number of R&D personnel above	
	environment	scale	+

# Table 2 Indicator System for the Level of Development of the Digital Econor

### 2.2.3 Mediating variables

Green innovation is measured by taking the logarithm of green patent applications (lngt), green utility model patent applications (lngu), and green invention patent applications (lngi).

### 2.2.4 Control variables

Level of opening to the outside world (open): expressed as the ratio of the total amount of goods imported and exported to the regional GDP; environmental regulation (ec): measured by the proportion of the completed industrial pollution control to the industrial value added; industrial structure (ls): expressed as the ratio of the tertiary industry to the secondary industry; level of technological marketization (tm): expressed as the ratio of the turnover of the technological market to the regional GDP; level of innovation (lninv): the logarithm of the number of invention patent applications

received; level of marketization (market): refer to the marketization index constructed by Fan Gang as the replacement variable in this paper. Logarithm of the number of invention patent application acceptance (pcs); Marketization level (market): refer to the marketization index constructed by Fan Gang as the replacement variable in this paper.

### 2.3 Data Sources

This paper utilizes the dynamic panel data of 30 provinces (except Tibet) in mainland China from 2012-2021 for evaluation and analysis, and the data are mainly obtained from Peking University Digital Inclusive Finance Index, China Statistical Yearbook, China Science and Technology Statistical Yearbook, China Rural Statistical Yearbook, China Industrial Statistical Yearbook, China Energy Statistical Yearbook, and the statistical yearbooks of each province, some of which are missing. data were processed by linear interpolation. Descriptive statistics of specific variables are shown in Table 3:

		Table 3	Descriptive	Statistics		
variable name	notatio	sam	averag	(statistics)	minim	maxi
	n	ple size	e value	standard deviation	um value	mum
						values
new mass productivity	Np	300	0.137	0.063	0.042	0.477
digital economy	Dig	300	2.135	0.845	0.576	4.547
Egypt's open- door policy towards the outside world	open	300	0.259	0.277	0.008	1.441
environmental regulation	ec	300	0.003	0.004	0	0.031
industrial structure	ls	300	1.283	0.711	0.549	5.297
Level of technology marketability	tm	300	0.017	0.030	0	0.175
Level of marketization	market	300	8.138	1.882	3.359	12.39
Innovation level	lninv	300	2.262	0.146	1.740	2.518

# **3 EMPIRICAL ANALYSIS**

# 3.1 Benchmark Regressions and Robustness Tests

According to the regression results in Table 4, this paper employs a two-way fixed effects model to systematically examine the relationship between the digital economy and new quality productivity. Column (1) shows that, without including control variables, the level of digital economy development has a significant positive effect on new quality productivity, with a regression coefficient of 0.069, statistically significant at the 1% level. To test the robustness of this conclusion, column (2) incorporates several control variables, such as the degree of outward orientation, environmental regulation, industrial structure optimization, transformation of scientific and technological achievements, and innovation capacity. The results indicate that the positive effect of the digital economy on new quality productivity persists after adding these variables. Column (3) replaces the control variables, and the regression results remain significant. Furthermore, to address potential endogeneity issues, the estimation is re-estimated using the 2SLS method, as shown in column (4). The level of digital economy development remains significant at the 1% statistical level, further confirming that the digital economy can promote new quality productivity. Additionally, the study addresses outliers by removing the extreme values in the 1st and 99th percentiles of the dependent variable and re-estimating the model. The results remain significant at the 1% level, indicating the robustness of the main findings. The study demonstrates that, even after considering other influencing factors, addressing endogeneity, and conducting robustness tests, there is consistently a significant positive correlation between the development of the digital economy and new quality productivity.

	Table 4 B	enchmark Regres	sion and Robustr	ess Tests	
	(1)	(2)	(3)	(4)	(5)
	Np	Np	Np	Np	Np
Dig	0.069***	0.023***	0.021***	0.093***	0.023***
	(0.006)	(0.006)	(0.007)	(0.009)	(0.005)
open		-0.120***	-0.108***	-0.022	-0.120***
		(0.021)	(0.024)	(0.014)	(0.020)
ec		-1.016*	-0.634	-0.105	-1.048*
		(0.522)	(0.583)	(0.709)	(0.548)

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ls		-0.003	0.028***	0.005	0.006
		(0.008)	(0.007)	(0.005)	(0.007)
tm		1.951***		0.268**	1.755***
		(0.191)		(0.122)	(0.175)
lninv		0.143***	0.016	-0.159***	0.123***
		(0.039)	(0.046)	(0.045)	(0.037)
market			0.017***		
			(0.003)		
Control	YES	YES	YES	YES	YES
Province	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
_cons	-0.010	-0.231****	-0.090	0.294***	-0.193**
	(0.013)	(0.082)	(0.094)	(0.089)	(0.080)
Ν	300	300	300	270	300
adj. $R^2$	0.237	0.586	0.489	0.682	0.615

Standard errors in parentheses\* p < 0.1,\*\* p < 0.05,\*\*\* p < 0.01, same in the following tables

# 3.2 GMM Test

To further explore the relationship between the digital economy and new quality productivity, this paper employs dynamic panel system generalized method of moments (SYS-GMM) and difference generalized method of moments (DIF-GMM) estimations. These methods effectively address endogeneity issues, yielding more accurate and robust results, as presented in Table 5. The SYS-GMM results indicate that the digital economy is statistically significant at the 1% level for new quality productivity (NQP). The coefficient of the first-order lagged NQP variable is 0.488, reflecting the strong path dependence and continuity of NQP. The DIF-GMM analysis also confirms the significant driving effect of the digital economy on new quality productivity. To assess the validity of the instrumental variables, the study conducts the Arellano-Bond test and Sargan test. The p-values of AR(1) and AR(2) pass the test, indicating serial correlation in the first-order difference perturbation term but not in the second-order difference perturbation term. The Sargan test p-value exceeds 0.1, failing to reject the null hypothesis, thus confirming the validity of the selected instrumental variables. Consequently, the conclusions drawn from the dynamic panel SYS-GMM and DIF-GMM analyses are credible.

Table 5 GMM Regression Results				
	System GMM	differential		
		GMM		
L.Np	$0.488^{**}$	$0.712^{***}$		
	(0.213)	(0.172)		
Dig	0.116***	$0.107^{***}$		
	(0.033)	(0.030)		
open	-0.063	$0.272^{**}$		
	(0.047)	(0.115)		
ec	0.273	-0.841		
	(0.878)	(0.579)		
ls	0.007	-0.029		
	(0.014)	(0.029)		
tm	0.063	0.342		
	(0.222)	(0.489)		
lninv	-0.343***	0.072		
	(0.096)	(0.076)		
Province	YES	YES		
Year	YES	YES		
_cons	0.612***			
	(0.178)			
N	270	240		
AR (1)	0.012	0.043		
AR (2)	0.395	0.206		
Hansen	0.131	0.549		

### **3.3 Mediation Effects Test**

To further illuminate the intrinsic mechanism through which the digital economy impacts new quality productivity, this study introduces green innovation as a mediating variable and empirically examines the relationships among the digital

economy, green innovation, and new quality productivity using a mediation effect model. The results, presented in Table 6, reveal a significant transmission mechanism. Employing green patent applications as an indicator of green innovation, the analysis demonstrates that, when controlling for other variables, the level of digital economy development exerts a significant positive impact on the number of green patent applications. Simultaneously, the influence of green patent applications on new quality productivity is significantly positive at the 1% statistical level. Moreover, as shown in Table 7, after incorporating the mediating variable of green innovation, the direct effect coefficient of the digital economy's development level on new quality productivity is 0.035, while the indirect effect coefficient is 0.019. The mediating effect accounts for 42.6%, indicating that green innovation plays a significant and partial mediating role in the process by which the digital economy affects new quality productivity.

To ensure the robustness of these findings, this study also adopts green utility model patent applications and green invention patent applications as proxy variables for green innovation. The estimation results remain consistent with the benchmark regression, confirming that regardless of the type of green patents, the digital economy indirectly enhances new quality productivity by promoting their development. The mediating effect accounts for 45% and 29.8% for green utility model patent applications and green invention patent applications, respectively. These results provide compelling evidence that the digital economy stimulates the vitality of green innovation, which in turn promotes the green transformation of the economy and elevates new quality productivity to a higher level. underscoring the crucial intermediary role of green innovation in the process of the digital economy empowering new quality productivity. This study contributes to the existing literature by elucidating the complex pathways through which the digital economy drives sustainable economic growth and development, highlighting the importance of fostering green innovation as a key mechanism in this process.

			Т	able 6 Mediat	ed Effects Te	est		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Np	lngt	Np	lngu	Np	lngi	Np
	Dig	$0.060^{*}$	1.337***	0.035***	1.332***	0.033***	1.355***	0.042***
		(0.003	(0.058)	(0.006)	(0.063)	(0.005)	(0.058)	(0.006)
	lngt	)		0.019***				
				(0.003)				
	lngu					0.020***		
						(0.003)		
	lngi							0.013***
								(0.003)
1	Contro	YES	YES	YES	YES	YES	YES	YES
1	Provin	YES	YES	YES	YES	YES	YES	YES
ce	Year	YES	YES	YES	YES	YES	YES	YES
	_cons	-0.004	5.441***	-	4.897***	-	4.525***	-
				0.109***		0.104***		0.064***
		(0.010	(0.159)	(0.020)	(0.173)	(0.017)	(0.160)	(0.018)
	N	300	300	300	300	300	300	300
	adj. $\mathbb{R}^2$	0.701	0.815	0.730	0.778	0.740	0.823	0.714

<b>Table</b> / Doolshap Test for Mediating Effects
--

variant	effect (scientific phenomenon)	efficiency value	BootSE	95% confidence interval	Percentage of intermediary effects
la et	direct effect	0.0346	(0.0068036)	(0.0212845,0.0479543)	42 60/
ingt	indirect effect	0.0257	(0.0046217)	(0.0166304,0.0347471)	42.0%
lngu	direct effect	0.0332	(0.0060294)	(0.021416,0.045051)	450/
iligu	indirect effect	0.0271	(0.0042727)	(0.0187002,0.0354491)	4370
Inci	direct effect	0.0423	(0.0075049)	(0.027554,0.0569727)	20.8%
Ingi	indirect effect	0.0180	(0.0050853)	(0.0080778,0.0280118)	29.870

### 3.4 Random Forest Model

To elucidate the nonlinear relationship between the digital economy and new quality productivity, this study employs the random forest model, a machine learning technique, to empirically analyze the underlying mechanisms. Figure 1 illustrates the biased dependence of new quality productivity on the level of digital economy development. The results reveal that as the level of digital economy development increases, its marginal contribution to new quality productivity exhibits a nonlinear characteristic, initially rising and subsequently declining. At low levels of digital economic development, the application and penetration of digital technology remain relatively limited, and the driving effect on new quality productivity is not yet fully manifest. However, as the digital economy enters an intermediate stage of development, the integration of digital technology with the real economy accelerates, fostering a two-way digital transformation of traditional industries. Consequently, the digital economy emerges as a potent engine for enhancing new quality productivity, with the two variables exhibiting a strong positive correlation.

As the digital economy progresses to higher levels of development, the low marginal cost of digital technology becomes ubiquitous across various domains of production and life. The marginal effect of releasing digital dividends diminishes, and the marginal contribution of the digital economy to new quality productivity tends to plateau. Figure 1, which depicts the marginal effect of the digital economy, corroborates these findings. The visualization illustrates that the marginal effect of digital economy development continues to climb from the low level to the medium-high level stage, amplifying its promotional effect on new quality productivity. However, when the digital economy advances to an even higher level, the marginal effect begins to decline, indicating the presence of diminishing marginal returns in the development of the digital economy.

The results presented in Figures 1 provide compelling evidence of a significant nonlinear relationship between the digital economy and new quality productivity. The impact of digital economic development on new quality productivity is characterized by distinct stages, verifying the research hypothesis posited in this paper. These findings contribute to the growing body of literature examining the complex, dynamic interplay between digitalization and economic performance, underscoring the importance of considering nonlinearities and stage-dependent effects in empirical analyses. By employing the random forest model, this study showcases the value of machine learning techniques in uncovering nuanced relationships that may be obscured by traditional linear modeling approaches, thus advancing the frontiers of scholarly understanding in this domain.



### **3.5 Threshold Effect Test**

To illuminate the heterogeneous effects of the digital economy on new quality productivity across different strata of innovation, this study employs a threshold regression model, introducing innovation level as a threshold variable. The results, presented in Table 8, reveal distinct nonlinear dynamics in the nexus between the digital economy and productivity. When green patent applications serve as the proxy for innovation level, the model identifies a single threshold value, bifurcating the sample into two regimes: high and low innovation. In the low innovation regime (Th  $\leq$  q1), the coefficient estimate for the digital economy development level is 0.011, statistically significant at the 5% level. Conversely, in the high innovation regime (Th>q1), the impact of digital economy development on new quality productivity intensifies, with the coefficient rising to 0.019, significant at the 1% level.

Adopting an alternative measure of innovation, namely green utility model patent applications, uncovers two thresholds, partitioning the innovation spectrum into three intervals: low, medium, and high. As the level of innovation ascends across these intervals, the coefficient estimate for digital economy development exhibits a monotonic increase from 0.009 to 0.023, accompanied by a concomitant enhancement in statistical significance from the 10% to the 1% level. Consonant results emerge when innovation level is proxied by green invention patent applications, with the model again identifying two distinct thresholds. The coefficient on digital economy development climbs from 0.014 in the low innovation regime to 0.028 in the high innovation regime, corroborating the proposition that the productivity-enhancing effects of the digital economy are accentuated as the level of innovation escalates.

The empirical evidence garnered from the threshold regression analysis lends credence to the hypothesis of a significant threshold effect of innovation on the relationship between the digital economy and new quality productivity. As economies ascend the innovation ladder, the marginal contribution of digital economy development to productivity growth amplifies, and the magnitude of the positive association between the two variables strengthens commensurately. These findings underscore the catalytic role of innovation in unleashing the potential of the digital economy to galvanize productivity growth. The results suggest that the innovation-driven development strategy will be instrumental in stimulating the digital economy's capacity to enhance new quality productivity. Therefore, expediting the

Table 8         Threshold Effect Model					
	(1)		(2)	(3)	
variant	lngt	variant	lngu	lngi	
(Th≤q)1	0.011**	$(Th \leq q)_1$	$0.009^{*}$	0.014***	
	(0.004)		(0.005)	(0.004)	
$(Th > q_1)$	0.019***	$(q_1 < Th \le q_2)$	0.017***	0.020***	
	(0.004)		(0.005)	(0.004)	
		$(Th>q_2)$	0.023***	0.028***	
			(0.004)	(0.004)	
_cons	-0.052**		0.000	-0.042**	
	(0.021)		(0.019)	(0.018)	
Control	YES		YES	YES	
Province	YES		YES	YES	
Year	YES		YES	YES	
N	300		300	300	
adj. <i>R</i> <sup>2</sup>	0.759		0.738	0.770	

construction of an innovation-oriented economy emerges as a policy imperative of paramount significance for realizing China's high-quality development objectives in the digital era.

# 4 CONCLUSIONS AND RECOMMENDATIONS

### 4.1 Main Findings

Using panel data from 30 Chinese provinces from 2012 to 2021, this study employs econometric and machine learning techniques to elucidate the impact of digital economy development on new quality productivity. The results reveal a robust positive correlation between digital economy development and new quality productivity, underscoring the digital economy's pivotal role in propelling high-quality economic growth.

Mediation analysis highlights the indispensable role of green innovation in the digital economy's impact on new quality productivity. The integration of digital technologies with green innovation stimulates eco-friendly industries and green transformation of traditional sectors, paving the way for a synthesis of economic progress and ecological civilization.

The random forest model uncovers a nonlinear relationship between the digital economy and new quality productivity, with the marginal contribution of digital technologies exhibiting an inverted U-shaped pattern. This finding calls for a targeted approach to digital economy development that harnesses digital technologies' multiplier effects while expanding their application domains.

Threshold regression analysis reveals the contingent nature of the digital economy's impact on new quality productivity, dependent on the prevailing level of innovation. As an economy ascends the innovation ladder, digital technologies' productivity-enhancing effects are amplified, underscoring the imperative of fostering a vibrant innovation ecosystem alongside the digital economy.

This study contributes to the literature on the digital economy and productivity by providing a comprehensive investigation of the complex mechanisms and boundary conditions shaping this critical relationship. The findings highlight the transformative potential of digital technologies in igniting new quality productivity growth and the indispensable role of green innovation and the broader innovation milieu. The research emphasizes the need for a holistic, innovation-centric approach to harnessing the digital economy as an engine of high-quality development.

### 4.2 Recommendations

First, catalyzing the Digital Economy as an Engine of High-Quality Growth To harness the digital economy's potential as a catalyst for high-quality development, policymakers must prioritize a multifaceted approach integrating innovation, sustainability, and institutional reform. Accelerating digital economy development requires reconfiguring the innovation landscape by deepening strategic layout, optimizing knowledge creation and diffusion mechanisms, and amplifying investments in research and translational activities. Fostering a confluence of innovation actors, economic sectors, financial resources, and enabling policy frameworks is crucial for nurturing a vibrant innovation ecology. A commitment to frontier research in core digital technologies is vital for seizing opportunities unleashed by the scientific and technological revolution, propelling industrial upgrading and economic transformation. Underpinning these endeavors is the cultivation of specialized human capital in digital intelligence, providing the intellectual bedrock for building a robust digital economy.

Second, strengthening the Wellsprings of Innovation-Driven Productivity To fortify innovation-driven productivity growth, a holistic strategy interweaving innovation systems, research investment, and talent development is indispensable. Policymakers must implement an innovation-driven development paradigm characterized by continuous refinement of institutional mechanisms for knowledge generation, diffusion, and application. Augmenting investment in

basic and applied research is crucial for expanding scientific understanding and catalyzing the translation of discoveries into tangible benefits. Facilitating seamless integration of innovation networks, industrial ecosystems, financial resources, and policy support fosters an enabling environment conducive to innovation-driven entrepreneurship. A resolute focus on surmounting technological bottlenecks and achieving strategic breakthroughs is paramount for capturing opportunities from the unfolding scientific and technological revolution. Underpinning these efforts is the systematic cultivation of a digitally-savvy, innovation-oriented talent pool with requisite skills and competencies to thrive in a knowledge-intensive economy.

Thrid,harmonizing Digital Transformation with Environmental Sustainability To achieve sustainable and inclusive digital transformation, policymakers must promote the harmonious integration of digital technologies with ecological conservation and low-carbon development. The ethos of environmental stewardship should permeate every facet of the digital economy, from technological solution design to data-driven market governance. Harnessing digital technologies' capabilities in optimizing resource allocation, enhancing energy efficiency, and minimizing environmental externalities is crucial for facilitating green upgrading of traditional industries. Policymakers should encourage the development of eco-friendly digital solutions, such as smart grids, precision agriculture, and intelligent transportation systems, which leverage data analytics and artificial intelligence to drive sustainable outcomes. Simultaneously, establishing dedicated green technology innovation ecosystems and investing in clean technologies and low-carbon infrastructure is vital for accelerating the deployment of cutting-edge solutions. By fostering a symbiotic relationship between the digital economy and ecological preservation, policymakers can chart a path towards a resilient, equitable, and sustainable future.

Fourth, deepening Institutional Reform and Global Integration To fully unlock the digital economy's potential, policymakers must commit to a comprehensive agenda of institutional reform and international cooperation. Accelerating the construction of a high-standard market system with fair competition, transparent regulation, and effective intellectual property protection is essential for fostering an enabling environment for digital innovation and entrepreneurship. Dismantling market entry barriers, combating monopolistic practices, and promoting a level playing field should be at the forefront of reform efforts. Concurrently, establishing an agile, adaptive governance framework for the digital economy is vital for ensuring the trustworthiness, security, and ethical integrity of digital technologies and data-driven business models. Policymakers should proactively engage in global dialogue and norm-setting processes to shape international governance of the digital domain, promoting principles of openness, inclusivity, and mutual benefit. Deepening cross-border collaboration in scientific research, technology transfer, and digital infrastructure development is crucial for harnessing the network effects and economies of scale inherent in the digital economy. By embracing a proactive stance towards institutional reform and international cooperation, policymakers can position their economies to thrive in an increasingly interconnected and knowledge-driven world.

### **COMPETING INTERESTS**

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

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# THE REVITALIZATION OF PUBLIC SPACES IN GUANGFU TRADITIONAL VILLAGES BASED ON SPACE SYNTAX: A CASE STUDY OF JIAOYUAN ANCIENT VILLAGE IN ZHAOQING CITY

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Abstract: Guangfu villages, as significant cultural heritage sites in the Lingnan region, possess spatial forms and historical-cultural values that merit in-depth study. However, with the advancement of modernization, the vitality and dynamism of public spaces in many traditional villages have gradually waned, leading to issues such as spatial decay and the disappearance of cultural imprints. The spatial morphological characteristics of villages serve as a crucial foundation for their analysis and study. This paper selects Jiaoyuan Ancient Village as the research subject and conducts field investigations to conduct a detailed analysis of its spatial structure, including road networks, public space layouts, and building distributions. With the aid of space syntax techniques, quantitative analyses are conducted on key elements such as the integration and intelligibility of the village, revealing the internal characteristics and potential issues of its spatial structure. Based on the results of the quantitative analysis, effective pathways for revitalizing the public spaces in traditional villages are proposed.

Keywords: Guangfu traditional village; Space syntax; Public space; Jiaoyuan Ancient Village

# **1 INTRODUCTION**

Traditional villages are formed through the long-term combined influence of various factors, representing a complex and diverse process. As an important component of cultural heritage, they carry rich historical, cultural, and social values. Traditional villages not only embody abundant living cultures but also serve as the spiritual home and repository of nostalgia for people. These living cultures include seasonal celebrations, temple fairs, life rituals, and more, which have been passed down through generations, forming the unique cultural traditions and customs of the villages.

Public spaces in villages are crucial carriers for villagers' daily activities, such as travel and cultural exchanges, and are mutually catalyzed by natural factors of the villages and villagers' living needs [1]. With the rapid development of urbanization, some traditional villages have experienced population outflow and hollowing, leading to the abandonment of a large amount of housing, land, and other resources within the villages. The functions of public spaces in villages, which are intended for social interaction, cultural promotion, and economic activities, have been severely lost, making it difficult for culture to be transmitted and continued. It is thus evident that traditional villages have become difficult to adapt to the current demands of urbanization development, and the development of traditional villages faces unprecedented challenges.

Under the guidance of the "Hundred Counties, Thousand Towns, Ten Thousand Villages Project," the implementation of the "High-Quality Development Project for Hundred Counties, Thousand Towns, and Ten Thousand Villages" has been proposed, with urban-rural integrated development as the main approach to comprehensively promote rural revitalization. The revitalization of village public spaces has become an important measure to promote the construction of harmonious and beautiful villages and facilitate urban-rural integrated development [2].

Based on the above situations, research in this field has gradually garnered attention, especially research on the revitalization of public spaces based on space syntax, which provides a new perspective for understanding and improving the spatial structure of traditional villages. However, existing research primarily focuses on case studies, lacking a systematic theoretical framework and comprehensive research. Further interpretation of culture, enrichment of case studies, enhancement of comprehensive research on cases, and exploration of potential pathways for future development are required.

Scholar Zhang Miaolin has explored in greater depth how traditional villages can better achieve transformation and revitalization in the context of urbanization. Taking Jianbei Village in Gaoping City, Shanxi Province as an example, the author analyzes the contradiction between the functions of public spaces and the living needs of villagers from multiple disciplines such as architecture and urban and rural planning. Through quantitative analysis, the author proposes revitalization approaches such as improving the living environment, beautifying street and alley spaces, and increasing the number of public spaces [3], aiming to restore the vitality of public spaces and promote the revitalization of villages. Notably, scholars Cui Wanyu and Yao Lei conducted quantitative research on the public spaces of Gudiao Village using space syntax theory and Depthmap software. Their research revealed the relationship between the integration of public spaces and village functions, finding that areas with high integration are typically the main interaction nodes of the village, while areas with low integration are mostly private spaces. Their findings emphasize the importance of public space design in promoting social interaction and suggest enhancing village vitality by improving the morphology of public spaces. At the same time, it is also worth noting that, as Xu Bolun et al. studied the narrative spaces of traditional

villages and explored the relationship between space and human memory. By combining space syntax theory with Depthmap software, they analyzed the constituent elements of narrative spaces [4] and proposed suggestions for protecting the narrative spaces of traditional villages, emphasizing the important role of space in cultural heritage. The research underscores the dual importance of conservation and utilization of traditional villages in the context of rural revitalization.

In this context, scholars Che Lu and Peng Huiyun discussed the spatial morphological characteristics of traditional villages, analyzing the "clustered axial" spatial structure of Tielu Village. Through quantitative analysis, they proposed that tourism projects and service facilities should be reasonably set up on the basis of preserving the original spatial form of the village, understanding the historical and cultural value of traditional villages, and rationally utilizing tourism resources to achieve sustainable village development. Scholar Liu Guiran conducted a systematic analysis of the public spaces in Xiongfan Village, pointing out that traditional villages are facing the crisis of destruction of their appearance and loss of vitality in the context of rapid urbanization. Using space syntax tools, he conducted a quantitative analysis of the structure of the village's public spaces, revealing the existing problems and proposing targeted revitalization strategies. [5] The research indicates that the revitalization of public spaces needs to be carried out in combination with the needs of villagers while maintaining the authenticity of the village, in order to maximize their social and cultural value.

Synthesizing the aforementioned literature, current research on the revitalization of public spaces in traditional villages has gradually formed a certain theoretical system and practical framework. Researchers generally adopt quantitative analysis tools such as space syntax to deeply explore the structural characteristics and social functions of public spaces and propose targeted revitalization strategies [5]. Although existing research has achieved certain results in both theory and practice, there is still room for further improvement in the depth and breadth of quantitative analysis. Additionally, future research can focus more on the integration of villagers' needs and cultural heritage to achieve sustainable development of traditional villages.

This study aims to explore the paths and strategies for revitalizing public spaces in Guangfu traditional villages based on space syntax. Specific research questions include: How can space syntax be utilized to study the public space morphology of traditional villages? What contradictions and challenges exist in local socio-cultural and commercial tourism aspects during the revitalization process? By analyzing the case of Jiaoyuan Ancient Village in Zhaoqing City, this study aims to investigate effective public space revitalization strategies to improve the spatial utilization of traditional villages, villagers' cultural identity, and commercial tourism value. Based on the analysis of space syntax, how should traditional villages revitalize and improve their public spaces? This question will permeate this study, providing more innovative paths and strategies for the revitalization of public spaces in traditional villages through syntactic deconstruction.

### 2 REGIONAL OVERVIEW AND RESEARCH METHODS

### 2.1 Overview of Jiaoyuan Ancient Village

Zhaoqing City, located in the central-western Pearl River Delta, serves as the core of Cantonese culture. Geographically, it sits in the transitional zone from the mountainous regions of western Guangdong to the plains, where the cultural system and Cantonese dialect are well-preserved. According to statistics from 2010, Zhaoqing boasts 39 traditional Cantonese villages, distributed in diverse locations.

Jiaoyuan Ancient Village, a 600-year-old Cantonese ancient village, is situated at the foot of Dinghu Mountain in Dinghu District, Zhaoqing, on a plain between Dinghu Mountain and Lanke Mountain, covering a total area of 126,000 square meters. The ancient building complex within the village occupies over 1,080 square meters, including Longxi Academy, the Ancestral Temple of Su Zhenren, the Ancestral Temple of the Liang Clan, as well as ancient houses, shops, ancient archways, and stone-paved alleys from the Ming and Qing dynasties. To the south of the village lies Dinghu Mountain, from which water is diverted through bamboo forests into a pond in front of the village, serving the villagers for irrigation, fire prevention, animal husbandry, and daily life. There are two large areas of ancient trees within the village, including 57 ancient trees of national first, second, and third grades, belonging to 13 species.

#### 2.2 Research Methods

Through literature review and data inquiry, we will examine the historical documents, local gazetteers, planning document, and other materials related to Jiaoyuan Ancient Village to gain insights into its cultural history and development.

Utilizing the theoretical analysis method of space syntax, we will employ the Depth Map-Beta 1.0 software to identify the main axes based on the road network and public space layout of Jiaoyuan Ancient Village. We will analyze convex spaces, with specific spatial morphology evaluation indicators including integration values (both global and local), choice values, intelligibility values, and synergy values. Based on the establishment of axis models and segment models, we will draw the axis map of Jiaoyuan Ancient Village in Depthmap to understand the accessibility and connectivity of convex spaces. Additionally, we will conduct a topological analysis of the axis map to explore the connections between nodes and comprehend the degree of aggregation of spatial elements. Finally, we will discuss the agglomeration, convenience, spatial composition of public spaces, and the relationship between public spaces and social activities based on the calculations of integration, connectivity, and depth values.

# **3** COMPOSITION AND SPACE SYNTAX ANALYSIS OF PUBLIC SPACES IN JIAOYUAN ANCIENT VILLAGE

### 3.1 Composition of Public Spaces in Jiaoyuan Ancient Village

### 3.1.1 Public node spaces

The public node spaces in Jiaoyuan Ancient Village are indispensable components of village life. They exist in various forms and functions throughout the village, providing villagers with abundant venues for public activities.

Ancestral Halls and Squares: The ancestral halls in Jiaoyuan Ancient Village serve as core nodes of the village, fulfilling functions such as sacrifice and assembly. According to statistics, there are three main ancestral halls within the village, attracting over 5,000 villagers to participate in various activities annually. The ancestral halls in Jiaoyuan Ancient Village are not only centers for family sacrifices and assemblies but also important carriers of the village's public spirit. Ancestral halls are often combined with squares, forming open and solemn spaces that host important rituals and daily social activities of the village. This layout embodies the traditional "cosmic schema" of "center, direction, domain, and group," strengthening the cohesion and identity of the village (Figure 1-2).



Figure 1 Liang Family Ancestral Hall



Figure 2 Su Zhenren Shrine

Water Wells and Street Intersection Nodes: As essential items for the daily lives of villagers, the well platforms surrounding water wells naturally become important places for villagers to fetch water and interact. There are a total of 12 water wells and street intersection nodes, with an average daily foot traffic of approximately 50 people per node. Additionally, street intersection nodes, as critical points for traffic distribution, also serve the function of daily social interaction among villagers. Although these node spaces are scattered throughout the village, they are interconnected, collectively forming a network of public life within the village (Figure 3-4).



Figure 3 Water Well



Figure 4 Street Lane

Naturally Formed Leisure Spaces: There are also some spontaneously formed leisure spaces in Jiaoyuan Ancient Village, such as those along riversides, beside streams, and under trees. These spaces, with their unique natural environments and cozy atmospheres, attract villagers to come for rest and entertainment, becoming indispensable public nodes within the village (Figure 5-6).



Figure 5 Rest Space



Figure 6 Street Lane

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### 3.1.2 Public linear spaces

The public linear spaces in Jiaoyuan Ancient Village are mainly composed of streets, water systems, and strip green landscapes, which connect various node spaces and form a complete public space system.

Street System: There is one main street and five secondary streets, totaling over 2 kilometers in length, connecting the main public buildings and residential areas of the village. The street system in Jiaoyuan Ancient Village is clear and orderly, with the main street connecting the main public buildings and transportation nodes of the village, while the secondary streets link the various residential areas within the village. The streets are not only pathways for villagers' daily travel but also important carriers for information exchange and material circulation within the village [6] (Figure 7).



Figure 7 Public Linear Spaces

Water System Landscapes: The streams surrounding the village total approximately 1.5 kilometers in length, with three ponds totaling 5,000 square meters in area, providing villagers with abundant natural landscapes and leisure spaces. Jiaoyuan Ancient Village is surrounded by streams and ponds, which not only provide the village with abundant water resources but also form unique natural landscapes. As an important component of linear public spaces, the water system not only serves transportation functions but also becomes an important place for villagers to relax and entertain (Figure 8).



Figure 8 Water System Landscapes

Riparian Greenbelts: There are multiple riparian greenbelt landscapes distributed throughout Jiaoyuan Ancient Village, such as the tree forests along the village edges and the street trees lining the roadsides. These greenbelt landscapes not only beautify the village environment but also serve ecological functions such as cooling and air purification. Additionally, they provide villagers with excellent destinations for leisure and strolling.

### 3.2 Spatial Syntax Analysis of Public Spaces in Jiaoyuan Ancient Village

After dividing and integrating the public spaces in Jiaoyuan Ancient Village, we translated its alley spaces into axial maps, imported these maps into the Depthmap spatial syntax software, established spatial topological relationships, conducted spatial syntax analysis, and employed quantitative analysis using spatial syntax parameters such as

integration, connectivity, and intelligibility [7]. This approach was used to explore the degree of connection and accessibility between spaces within the village, providing a more intuitive representation of the spatial morphological characteristics of Jiaoyuan Ancient Village.

## 3.2.1 Integration analysis

Integration is an important parameter for measuring the publicity and accessibility of individual spaces [8]. Spaces with high integration are functionally concentrated areas, indicating that these individual spaces have high centralization and spatial accessibility, and vice versa [1]. Among them, global integration (Rn) represents the degree of connection between a certain space and all other spaces in the system; local integration (R3) refers to the degree of connection between a certain space and other spaces connected within three topological units.

# ① Global Integration

According to the figure, in the global integration analysis of Jiaoyuan Ancient Village, the obtained "normalized average" is 0.134, with a maximum value of 1.302 and a minimum value of 0.517. The data results show that the village has good spatial accessibility and overall tight connectivity. By referring to the descending order of integration values, we can analyze that the core area is a horizontal region connected by Longxi Academy, Liang Family Ancestral Hall, and Qianguang Kindergarten. Along the axis of this building cluster, the value reaches the maximum of 1.302. As these three buildings serve as the core and spread outward, the axis colors gradually change from warm to cold, i.e., the integration values decrease from high to low, indicating that the degree of spatial aggregation gradually decreases, and the spatial form shifts from concentrated to dispersed. This suggests that the layout of these three core buildings influences the positioning of the core spatial areas within the village.

### ② Local Integration

Local integration refers to the configurational relationships within local areas of the entire site [9]. It allows for the analysis and extraction of potential core areas within various regions. In the local integration analysis of Jiaoyuan Ancient Village, combined with the local integration map, we can see that the "normalized average" value is 0.446, with a maximum value of 3.643 and a minimum value of 0.333. By referring to the descending order of values, the analysis results show that local integration analysis divides multiple local core areas, corresponding to various traditional building nodes within the village. Comparing this with the global integration analysis, global integration (0.134) is less than local integration (0.446). Furthermore, the warm and cold colors between axes indicate that in Jiaoyuan Ancient Village, the spaces within each core area are tightly connected and have their own organizational structures, respectively forming unique alley road systems for each region.

### 3.2.2 Connectivity analysis

Connectivity refers to the degree of influence between spaces within the entire street and alley system, i.e., the number of other spaces directly connected to a given space. It reflects the connectivity and permeability between spaces. A higher connectivity value indicates stronger spatial permeability and higher accessibility, whereas a lower value indicates the opposite. [10] In the connectivity analysis of Jiaoyuan Ancient Village, the "normalized standard deviation" is approximately 2.562, with a maximum value of 22 and a minimum value of 1. This indicates that the alley and road systems within the ancient village are intricate and complex, and the intertwined road network enhances the accessibility within the village to a certain extent, providing multiple travel options for people. According to the connectivity map, the values near various traditional ancestral halls and other public space nodes within the village range between 9 and 15, suggesting that the traditional public spaces in the ancient village have strong permeability and high accessibility. Consequently, other spaces within the village can reach these traditional public space nodes, which have gradually become gathering places for villagers.

# 3.2.3 Average depth value analysis

The average depth value describes the accessibility and convenience of a node within a spatial system, representing the average of the shortest distances (i.e., number of steps) from a node to any other node in the connection graph. It reflects the topological accessibility of a node, i.e., the number of transitions required within the spatial system. A higher depth value indicates more transitions, more complex paths, and lower accessibility and convenience, whereas a lower value indicates the opposite. [11] In the average depth analysis of Jiaoyuan Ancient Village, the "normalized average value" is 59.163, with a maximum value of 370 and a minimum value of 6. From the average depth value analysis map, it can be seen that the roads within the ancient village are intricate and span the entire village. The road system is highly dense, making it easy for tourists and other outsiders to get lost within the village.

# 3.4.4 Intelligibility analysis

Intelligibility reflects the correlation between local and global variables, using the function y=ax+b (linear regression equation) to simulate the trend of the scatter plot. Here, R<sup>2</sup> represents the goodness of fit. A value greater than 0.5 indicates that it is easier to perceive the overall space from local spaces, whereas a lower value indicates it is more difficult. [12] This expresses the ease or difficulty of establishing an understanding of the overall space through comprehension of the local spatial characteristics within a holistic space. In the intelligibility analysis of Jiaoyuan Ancient Village, the "optimized goodness of fit (R<sup>2</sup>)" value is approximately 0.37. Therefore, the optimized goodness of fit for Jiaoyuan Ancient Village is 0.37 < 0.5, indicating that the local spaces within the village are not well integrated into the entire street and alley system. To a certain extent, tourists and other outsiders find it difficult to understand the spatial structure of Jiaoyuan Ancient Village (Table 1, Figure 9).



Maximum 370.000 Std Dev 59.163

### Understandability



Figure 9 Overall Axial Analysis Diagram of Spatial Syntax in Jiaoyuan Ancient Village

### 4 STRATEGIES FOR REVITALIZING PUBLIC SPACES IN JIAOYUAN ANCIENT VILLAGE

#### 4.1 Optimization and Revitalization of Pedestrian Spaces and Alley Systems

Utilizing the theory of spatial syntax for an in-depth analysis of the traditional alleys in Jiaoyuan Ancient Village aims to precisely identify high-frequency pedestrian areas. By focusing on revitalizing these areas and strengthening their connections with surrounding spaces, functional spaces suitable for modern life can be constructed. Specific measures include transforming the open space under the ancient banyan tree into an educational green space, optimizing the traffic environment in the old village center, and strengthening the interaction with adjacent ecological farmland. To achieve a harmonious balance between sustainable development and the preservation of traditional features, Jiaoyuan Ancient Village is divided into three major zones: a core protection zone, an infrastructure optimization zone, and a zone for harmonious coexistence between humans and nature. While maintaining the texture of traditional alleys, the infrastructure optimization zone delves deep into cultural genes and historical features to formulate protection measures. Leveraging cultural resources to create unique cultural brands is expected to significantly increase pedestrian traffic in the alley spaces.

### 4.2 Improving the Village Transportation Network and Living Environment

Through quantitative analysis of the overall public spaces in Jiaoyuan Ancient Village, the shortcomings of the village's external transportation and the fact that its deep-level spatial form and structure are not recognized by the migrant population have been identified, for which corresponding improvement measures should be formulated. These measures aim to enhance the village's transportation convenience, strengthen the industrial and transportation attributes of peripheral village roads and urban trunk roads, and increase the core competitiveness of roads and the convenience of transportation both inside and outside the village, thereby facilitating residents' lives.

### 4.3 Preserving Village Historic Sites and Preserving Cultural Pulse

Key protection areas and buildings within the village have been identified, and the cultural genes and historical features of Jiaoyuan Ancient Village, such as traditional architecture and legendary stories, have been deeply explored for archiving and preservation. Meanwhile, leveraging the village's cultural resources to create distinctive cultural brands, such as hosting cultural festivals and developing cultural and creative products, not only enhances the village's popularity and influence but also strengthens cultural education and inheritance, fostering villagers' cultural self-confidence and identity.

### 4.4 Supportive Measures and Villager Participation in Jiaoyuan Village

Jiaoyuan Village offers practical incentive benefits by establishing a special fund to support the infrastructure construction, ancient building restoration, and cultural tourism project development for the revitalization of public spaces in historic villages. Additionally, it actively guides social capital investment into revitalization projects of public spaces in historic villages, attracting more funds and resources into the conservation and development of historic villages through PPP (Public-Private Partnership) models, equity financing, and other means.

To enhance villagers' cultural identity and sense of belonging, the value and significance of Cantonese traditional culture are promoted among villagers through cultural activities and the construction of cultural facilities, fostering their cultural self-confidence and identity. Villagers are encouraged to actively participate in and contribute to the compilation of historical village materials, joining in the revitalization and renovation of public spaces. A preservation and development committee composed of villager representatives is responsible for daily maintenance and repairs.

### 5 CONCLUSION

Through quantitative analysis using space syntax, this paper objectively and accurately represents the current spatial situation, delves into the issues surrounding the decline in vitality of public spaces in traditional villages, and proposes corresponding countermeasures [13]. The analysis using space syntax focuses on the spatial form itself, while also considering historical, social, and cultural factors. When revitalizing the public spaces of villages, it is important to prioritize the preservation of the integrity and value of village culture, respect the wishes of the villagers, and align with the guidance of the "Hundreds, Thousands, and Myriads Project". By continuing to invest the economic returns from village cultural tourism into village construction, more precise requirements and suggestions can be put forward, providing valuable reference for the revitalization of public spaces in similar traditional villages.

### **COMPETING INTERESTS**

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

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# INNOVATION AND PRACTICE OF APPLIED TALENT CULTIVATION MODE FOR INDUSTRY-EDUCATION INTEGRATION OF NEW BUSINESS STUDIES BASED ON TOPIA

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Abstract: In the context of the major change of "cognitive revolution - business reshaping - management logic technology empowerment" evolution initiated by the fusion application of "Great Intelligence, Mobile, Cloud, Physical Area", the TOPIA Modern Industrial College Learning Organization (TOPIA) has been established based on the framework of "Four Chains + Five Communities" fusion. Based on the "four-chain + five-community" integration framework, TOPIA Modern Industrial College puts forward the industry-education integration and applied talent cultivation model, i.e., "Knowledge-Competence-Quality" target system (Target), establishes the Modern Industrial College Learning Organization, relies on the three-dimensional composite value platform (Platform), connects with the modern industrial college, and provides a platform for the development of the modern industrial college. Platform, linking the integration of resources of multiple subjects, multiple interfaces, multiple levels and multiple dimensions, carrying out a series of activities for the integration of industry and education, and realizing the cultivation of composite and applied talents in modern industrial colleges; based on the parallel and distributed processing action mode, using the theory of multi-stage and multi-loop, identifying the key innovation of talent training mode in the process of the integration of industry and education in modern industrial colleges. Based on the parallel distributed processing action model, using the multi-stage multi-loop theory, identifying the key elements of talent cultivation mode innovation in the process of industry-teaching integration of modern industrial colleges, we have constructed and implemented the talent cultivation program of "equal emphasis on theories and practices, double goodness of technology and profession, and integration of knowledge, ability and quality"; we have carried out the cultivation of practical ability and innovation ability throughout the reform of teaching contents and teaching methods, the construction of curriculum system and teaching materials, and the construction of teaching staff and personnel. The program promotes the improvement of employment quantity and quality.

Keywords: TOPIA; New business; Applied talent cultivation; Innovative models

### **1 INTRODUCTION**

Along with the implementation of policies such as "China Education Modernization 2035" and "Outline of the 14th Five-Year Plan for the Development of National Education", and the major changes of "cognitive revolution - business reshaping - management logic - technological empowerment" initiated by the convergence of new technologies such as big data and cloud computing, economic management theories based on the industrial revolution have fallen into confusion about the theoretical interpretation of the digital economy<sup>[1]</sup>. The major change of "cognitive revolution business reshaping - management logic - technology empowerment" and the theoretical explanation of the digital economy based on the economic management theory of the industrial revolution have fallen into a maze, and the multiple superposition of new pattern, new technology, new mode, new theory and new requirements will inevitably bring about paradigm shifts and challenges to the traditional business education<sup>[2]</sup>. How to break through the path dependence, give full play to industrial advantages, highlight the role of enterprise education, and deepen the integration of industry and education has become the key factor to solve the problem of seamless articulation of "industry, academia, research and application of funds", and how to innovate and practise diversified talent cultivation modes through the integration of industry and education has become the key to the reform of higher education with high-quality development as the center of the reform, and to comprehensively improve the ability of talent cultivation and create a large number of talents who are needed by industries<sup>[3]</sup>. The innovation and practice of diversified talent cultivation mode of industry-teaching integration has become an effective way to reform higher education focusing on high-quality development, comprehensively improve talent cultivation capacity, and create a large number of high-quality composite, innovative, and applied talents needed by industries<sup>[4][5]</sup>.

The main pedagogical issues addressed in this study are as follows:

(1) It solves the problem of how to cultivate applied talents in the new business discipline by focusing on students to meet the needs of business talents for economic and social development, and cracks the "black box" of "knowledge-capability-quality" transformation efficiency in the whole process of teaching.

(2) It solves the problem of how the integration of industry and education between school and enterprise subjects in the process of cultivating applied talents in the new business discipline can be shifted from loose connection to physical embedding, and realize the overall leap in the ability of collaborative education and industry in educating people.

(3) It solves the dilemma of talent cultivation orientation of applied undergraduate colleges and universities in the stage of massification of higher education, responds to the value demands of multiple educational interests including society, enterprises and even families, and promotes the achievement of the goal of high-level applied talent cultivation.

# **2** CONSTRUCTION OF THE THEORETICAL FRAMEWORK OF "TOPIA" INDUSTRY-TEACHING INTEGRATION AND APPLICATION-ORIENTED TALENT CULTIVATION MODEL

Against the background of the major change from "cognitive revolution - business reshaping - management logic technology empowerment" initiated by the integration application of "big intelligence, mobile, cloud and object area", the six concepts of talent training for the new business discipline are put forward: the view of the times, the view of digital intelligence, the view of values, the view of the system, and the view of specialties, The practical view<sup>[6]</sup>; with the new concept, the professional talent cultivation goal is clarified, and the new business integration TOPIA applied talent cultivation model is created, i.e. builds the target system of "Knowledge-Competence-Quality" for the integration of industry and education, establishes a new form of organization of the modern industrial college, and relies on the three-dimensional composite value platform (organization), which is the most important platform in the industry<sup>[7]</sup>. The three-dimensional composite value platform (Platform), linking multi-subject, multi-interface, multi-level and multi-dimensional resource integration (Integration), carrying out a series of industry-education integration activities (Activity), to realize the cultivation of new business majors of composite, innovative and applied talents; construction and implementation of the "Theory and practice, technology and professional both good, knowledge, ability and quality" target system (Target).; construct and implement the talent cultivation program of "both theoretical and practical, technical and professional, and integrating knowledge, ability and literacy", and carry out the cultivation of practical ability and innovation ability throughout the reform of teaching content and teaching methods, the construction of curricula and teaching materials, and the construction of teaching staff, etc., so as to promote the improvement of the quantity and quality of employment.

### 2.1 Target

Establishment of "knowledge-capability-quality" application-oriented talent cultivation target. Following the social demand, adapting to the practical development requirements of the industry and enterprises, combining with the characteristics of local colleges and universities and the unique attributes of new business majors, and fitting in with the cultivation concepts of the era view, numerical wisdom view, value, system view, characteristic view and practical view, we will establish a high-level applied talent cultivation target of "knowledge-capability-quality" for the integration of industry and education and the all-round development of morality, intellectuality, physical fitness, aesthetics, labor and so on. It also aims to establish the goal of cultivating high-level applied talents with the integration of industry and education, and to solve the contradiction between supply and demand, which is the mismatch between the specifications of talent cultivation and the ability demand of enterprises' positions.

# 2.2 Organization

Creation of "Modern Industrial College", a new form of industry-education integration organization. We have established "Shengbao Financial Technology Industry College", "Jingdong Intelligent Logistics Industry College", "Transfar Supply Chain Industry College" and "Fosun Intelligent Tourism Industry College" together with the head enterprises. Fosun Wisdom Tourism Industry College", forming the industrial development chain of "resource demand, job demand, technical service and achievement transformation", the talent team of "on-campus professional tutor + innovation tutor + entrepreneurship tutor + enterprise tutor", and the "theoretical foundation + entrepreneurship tutor + enterprise tutor" chain. chain, professional education chain of "theoretical foundation + professional direction + industrial direction", and innovation training chain of "creative ability + innovation ability + entrepreneurial ability", to build the modern industrial college of "resource sharing - professional co-construction - technical It builds the talent cultivation model of "resource sharing, professional co-construction, technology co-research, win-win development and value consensus" of Modern Industrial College, and effectively promotes the members of the organization to transform "knowledge-capability-quality" into the practice of industry-teaching integration.

### 2.3 Platform

Build a composite value platform to realize the seamless connection of official department, industry, academia, research and application. A teaching platform, a research platform, a practical training platform and an innovation and entrepreneurship platform have been set up to realize the three-dimensional interaction and organic integration of teaching and research, theory and practice, inside and outside the classroom, online and offline, innovation and entrepreneurship. ①Teaching platform. Theoretically, we have built a framework system of basic knowledge, specialized knowledge and technical knowledge, and practically, we have constructed modules of industry cognitive internship, single quality training, comprehensive quality training, digital skills and innovation and entrepreneurship; ② scientific research platform. Relying on Hainan Silk Road Business Civilization and other three provincial research bases, China Human Resource Development Research Society and other more than 10 academic organizations to hold academic conferences and thematic activities, to carry out research on horizontal and vertical topics; ③ practical

training platform. According to the actual labor demand of enterprises, we reasonably formulate and adjust the talent training program, scientifically arrange practical teaching, and dispatch students to Geely Group, Sanya Atlantis, Shanghai Disney and other more than 20 head enterprises in stages to carry out various types of practical teaching including "3+1" internship mode, forming the process of talent training from theory to practice, multiple cycles, effective and efficient. It forms a closed loop of multiple cycles and effective feedback from theory to practice, realizing accurate talent cultivation according to the needs of industry positions; ④ Innovation and Entrepreneurship Platform. We have set up an innovation and entrepreneurship incubation base for college students and an academic guidance center to incubate and guide many on-campus innovation and entrepreneurship teams.

# 2.4 Integration

linking the value resources of multiple subjects, multiple interfaces, multiple levels and multiple dimensions to realize value co-creation. In the practice of industry-education integration, we adhere to the principles of "administrative guidance, school leadership, expert guidance, teacher-student leadership and enterprise counseling", relying on online and offline resources, promoting resource integration, information sharing and knowledge updating, establishing a common vision, forming a team to learn, improving the mental model, adhering to the systematic thinking, and realizing self-transcendence.

# 2.5 Activity

Relying on the interface of "cultivation goal + industrial college + value platform + resource integration", we will carry out the integration of industry and education to jointly formulate cultivation programs, faculty construction, curriculum and teaching materials construction, practical teaching and employment, scientific research, and the transformation of achievements and technical services, so as to effectively promote the cultivation goal of "giving equal importance to theory and practice" and "integrating knowledge, ability and literacy". The integration of industry and education has effectively promoted the cultivation goal of "equal emphasis on theory and practice, double excellence in technology and specialization, and integration of knowledge, ability and literacy".

# **3** TOPIA NEW BUSINESS INTEGRATION OF INDUSTRY AND EDUCATION APPLIED TALENT TRAINING INNOVATION PATH

# 3.1 Model Innovation: Proposing a New Business "TOPIA" Applied Talent Training Model

With the goal of cultivating compound and applied new business talents, we innovatively put forward the "TOPIA" applied talents cultivation model, i.e., the target system of "Knowledge - Ability - Quality", set up a new organizational form of modern industrial college (Organization), rely on a three-dimensional composite platform (Platform), and connect the integration of resources of multiple subjects, multiple interfaces, multiple levels and multiple dimensions (Integration). Organization), relying on the three-dimensional composite platform (Platform), linking multi-body, multi-interface, multi-level and multi-dimensional resources integration (Integration), to carry out a series of industry-education integration activities (Activity).

# **3.2** Organizational Innovation: Adhering to the Principle of "Four Chains and Five Common", Creating a Learning Organization for Modern Industrial Colleges

We have created four modern industrial colleges with the common vision of cultivating new business applied talents, namely, the formation of the industrial development chain of "resource demand, job demand, technical service and achievement transformation", the talent team chain of "on-campus professional tutor + innovation tutor + entrepreneurship tutor + enterprise tutor", the professional education chain of "theoretical foundation + professional direction + industrial direction" and the innovation cultivation chain of "creativity ability + innovation ability + entrepreneurship ability". It is the organic integration of four chains, namely, the industrial development chain of "resource demand, job demand, technology service and achievement transformation", the talent team chain of "on-campus professional tutor, innovation tutor, entrepreneurship tutor and enterprise tutor", the professional direction and industrial direction" and the innovation cultivation chain of "creativity, innovation cultivation chain of "theoretical foundation, professional direction and industrial direction" and the innovation cultivation chain of "theoretical foundation, professional direction and industrial direction" and the innovation cultivation chain of "creativity, innovation and entrepreneurship". Professional co-construction - technology co-research - development win-win - value consensus" five common linkage of industry-teaching integration and applied talent cultivation model.

# **3.3** Platform Innovation: Integrating "On-Campus + Off-Campus" Resources, Building a Three-Dimensional Composite Value Platform

A four-in-one platform of "teaching platform + scientific research platform + practical training platform + innovation and entrepreneurship platform" has been set up to realize the three-dimensional interaction and organic integration of teaching and scientific research, theory and practice, in-course and out-of-course, online and offline, innovation and entrepreneurship.

# 3.4 Institutional Innovation: Integrated Institutional Innovation of "System + Team + Governance + Technology"

Scientific positioning of talent cultivation objectives according to the actual needs of enterprises and industries, and the realization of interdisciplinary and inter-professional cross-disciplinary and continuous iteration of cultivation specifications and curricula; innovation of cross-boundary co-construction system of team: "on-campus + off-campus" mentor team of multiple subjects co-teaching and co-learning; innovation of dual-governance system of governance: dean's responsibility system as the core, and the enterprise Dual governance system innovation: the dean's responsibility system as the core, and the enterprise Dual governance system innovation: the dean's responsibility system as the core, the enterprise's professional staff as the axis, supplemented by the dual governance structure of the Teaching Committee and the Academic Committee; digital-enabled system innovation: with the goal of cultivating applied talents, the scientific governance and organic integration of the four key links of teaching decision-making, teaching implementation, teaching supervision and teaching evaluation are driven by data governance and information sharing.

### 4 RESPONSES AND RECOMMENDATIONS

#### 4.1 Focus on the Integration of Industry and Education and Deepen the Reform of Professional Construction

Applied talent training should focus on the integration of industry and education, and deepen the reform of professional construction. Specialization is the basic unit of personnel training, the integration of industry and education background, the training of applied personnel to the professional chain and industrial chain of two different individuals can really integrate highly dependent on the professional co-construction between colleges and universities and industry enterprises, only the industrial chain and the professional even the depth of the docking, the professional into a "gold specialist". First, top-level design. School level should set up the integration of industry and education office, external cooperation office, and various faculties of the integration of industry and education leading group, improve the integration of industry and education system design, the introduction of a series of guidelines conducive to the integration of industry and education, at the same time, the colleges according to the top-level design of the school were introduced to correspond to the faculty of the integration of industry and education landing guidelines to determine the top-down "co-ordination of joint deployment and joint action, prioritize the development of Synchronized updating, bottom-line thinking of the head standard, and strength enhancement of results evaluation" are the basic principles of integration of industry and education, and the path of integration of industry and education with multi-departmental, multi-level, and multi-dimensional linkage is established, so as to compact the organs, strengthen the colleges, and press the delivery platform, and to promote the integration of industry and education and the work of downward sinking and downward shifting of the center of gravity. Focusing on the overall strategic goal of industry-education integration, making full use of the eco-chain resources of external industry enterprises to jointly build modern industry colleges, industry-education integration communities and other virtual-realistic cross-organizational cooperation units, based on the real business processes of enterprises, developing and optimizing the applied undergraduate talent cultivation system with head enterprises, identifying the core key of the industry industry, aligning with the mid- and upper-streams of the industry chain, and connecting with the needs of high-value positions in the enterprises, and Revise the talent cultivation program; build a curriculum system in line with the talent cultivation orientation of modern industrial colleges, customize and develop modular courses based on the whole production and manufacturing scenarios of business flow, information flow and data flow of the head enterprises, and improve the application-oriented curriculum system; promote the classification and evaluation, and guide the second-level colleges and majors to determine the development orientation and school running direction according to the content planning of the work of industry-industry-teaching integration, and highlight the characteristics of the education that closely combines the practice of industry-industry-teaching integration with the industry The special education that closely integrates with enterprises, the dissertation (graduation design) guidance from the front line of production, and the evaluation of the degree of integration between the development of graduates and professional education, etc., will form the collaborative practice results of the professional benchmarking outputs and the head enterprises' bidirectional running, collaborative symbiosis, mutual empowerment, and mutual honor. Introducing enterprise front-line operation platforms, application scenarios and real production practice cases on campus, "real problems really do", realizing the synchronization between the quality of talent cultivation and the standards of industry positions, and advancing with the industry, combining the urgent and future needs of industry and industry, as well as the innovativeness of the cultivation of applied talents, and carrying out the declaration of relevant new majors, the development of new directions and the innovation of characteristics of school-enterprise cooperation on a regular basis every year. We regularly carry out a series of work such as declaration of new majors, development of new directions of majors, and construction of school-enterprise cooperation classes of innovative talents with special characteristics every year. Aiming at the goal of high-value jobs corresponding to specialties, the university improves the concepts and methods of education and teaching, and continuously focuses on cultivating talents who are widely welcomed by the jobs of related organizations in the industries.

### 4.2 Focus on Product Thinking, Deepen the Curriculum Teaching Reform

Education reform to the depths of the curriculum, the curriculum is the core element of talent training, applied talent training curriculum should be closely combined with the development of the industry and the establishment and promotion. Under the background of the integration of industry and education, the cultivation of applied talents to break the asymmetric knowledge barriers between the professional chain and the industrial chain is highly dependent on the co-construction of the curriculum between universities and industrial enterprises, which in turn promotes the chemical reaction of students' knowledge learning and the quality of the leap. Focusing on products, linking with industries and targeting high-value jobs, we explore the curriculum teaching reform based on product thinking through ability inversion, knowledge reorganization, anchoring employability enhancement, accelerating team transformation, evaluation steering, and promoting productivity revitalization. Driven by market and customer thinking, starting from the competency of organizational high-value positions, inverting the curriculum knowledge map, focusing on the production of enterprise products from the perspective of the industrial Internet, promoting the docking of course content with the actual business processes of enterprises, the articulation of the course system with the industrial division of labor system, and the linking of the course ecosystem with the industrial ecosystem, and carrying out all-around product-thinking oriented featured courses with the emphasis on the reorganization and integration of the course teaching contents. Reform, highlighting the curriculum construction in line with the actual teaching of the curriculum and the needs of industry and enterprises and the cultivation of students' practical ability, constructing a dual-combination curriculum teaching reform operation mechanism of "combining the process with the results, combining on-campus and off-campus", evaluating the curriculum and the effect of the curriculum with a result-oriented approach, emphasizing the "business ability cultivation" of the applied curriculum, and providing a comprehensive and comprehensive training system for the students. We emphasize the "cultivation of management ability" in the applied courses, and at the same time innovate and enrich the forms and methods of the courses with the "flow thinking", so as to attract the students to benefit from the course learning in a sustainable way. Continuously aiming at the requirements of high-value positions and employment needs of enterprises, dynamically adjusting the curriculum and teaching arrangements, designing modularized teaching contents, synchronizing the contents of the curriculum and teaching materials with the actual business of production and operation of enterprises, and keeping them innovative and forward-looking, integrating the activities of pre-service training of enterprise employees and other in-house training activities as the front-end of the professional cognition and guidance for new students' enrollment, graduation and employment guidance, etc., and integrating the production line, business flow and other information of industry enterprises into the teaching and learning process of the school. The company will move the actual scenes of production lines, business processes, operation and management of industrial enterprises into the campus, invite technical personnel of enterprises to carry out skills training in the school, incorporate the quality management standards into the students' experimental and practical training assessment, and incorporate the production standards, technical standards and safety standards into the evaluation system of the course teaching, so as to let the evaluation standards realize the combination of process and result, and the combination of on-campus and off-campus, and check whether the quality of the course teaching really reaches the intended goal, and construct the production and training system. Whether to really achieve the intended goals, build a new ecology of the integration of production and education curriculum construction, through the integration of production and education "last kilometer".

### 4.3 Focus on Industry Needs and Deepen the Reform of the "Industry-Teaching" Faculty

Education reform to the pain is the teacher, industry-teaching integration of applied personnel training quality really plays a role in determining the teacher, and industry-teaching integration of applied personnel training of the faculty if there is no industry-teaching through the new "dual-teacher" that is a fantasy, therefore, the integration of industry-teaching is the cultivation of industry-teaching through the new "dual-teacher" teachers. Therefore, the integration of industry and education is the necessary way to cultivate new "dual teachers" of industry and education. Specifically, highlighting the employment goal orientation of teaching quality, focusing on cultivating teachers' industry experience, part-time jobs and social contribution of technical achievements and support for talent cultivation, etc., to accurately categorize the teaching force, integrate the stock of resources, take the integration of industry and education as an opportunity to strengthen the construction of a new type of "dual-teacher" teachers, and promote the "introduction of enterprises into the teaching" program. With the opportunity of industry-teaching integration, we will strengthen the construction of new dual-teacher talents of "industry-teaching", promote the collaborative education mode of industry-teaching integration of "attracting enterprises into teaching" and "pushing teaching into enterprises", actively promote the construction of teacher teams by schools and enterprises, and jointly promote the convergence of curriculum content and technological development, the docking of the teaching process with the production process, and the fusion of talent cultivation with industrial demand. Adopt online and offline hybrid teaching mode, and jointly create the "expert class" for industry-enterprise integration. Strengthen the interaction and exchange of teachers, build the cooperative unit of industry-teaching integration (modern industrial college, industry-teaching integration community, etc.) into a high-quality "dual-teacher, dual-competence" teacher training base, regularly send teachers of different classifications to work in the industry-enterprise, coordinate with the enterprise mentors to teach in the school, and build a team of teachers with profound theoretical foundation and rich practical experience. The team of high-level teachers with complementary advantages and synergistic linkage. Focusing on the results of the integration of industry and education and the ability to transform the results, we vigorously carry out the improvement of teachers' education and teaching ability and digital literacy training; according to the characteristics of different disciplines and positions,

we adhere to the classification and evaluation, and encourage the teachers to apply the theoretical innovations and cutting-edge technologies to solve the major engineering and technological problems of the industry (enterprises), and at the same time feed back to the classroom teaching, so that a group of high-level dual-teacher, dual-capable teacher team can be formed.

# 4.4 Focus on Digital Transformation and Deepen the Blended Teaching Reform of Industry-Teaching Integration

With the multi-dimensional changes embedded in the expansion of social information, the ubiquity of educational resources, the rapidity of occupational mobility, the empowerment of science and technology, the normalization of lifelong learning, and the personalization of learning content, traditional teaching is no longer able to satisfy the above dynamic scenarios, and focusing on digital transformation has become a must to solve the above dilemma. Educational reform is transformation in practice, the formation of new educational resources and technological innovation to enhance educational capacity, research and development of high-quality integration of industry and education combined with the digital construction of the curriculum path, digital technology to achieve the educational objectives of the integration of industry and education, and the use of digital technology to enhance the effectiveness of education and teaching evaluation. Make full use of digital teaching platforms and highly immersive teaching scenarios, share expert resources, technical resources and scenario experience resources of the industrial ecology, as well as school and enterprise online course resources taught by academicians, experts, industry leaders, management and technical backbones, etc., and teacher resources, course resources and experimental condition resources jointly built by schools and enterprises, etc., while focusing on the construction and accumulation of databases and corpora required for specialties, courses and cases, etc., and actively promote online and offline hybrid construction. It also focuses on the construction and accumulation of databases and corpora required for specialties, courses, cases, etc. It actively promotes the reform of online and offline blended teaching, develops online teaching evaluation standards, improves the digital literacy of teachers through the all-round digital cultivation of teachers, and initiates the development of the phased evaluation of the growth of students' learning achievements and the evaluation of the whole process of four years of study in universities. Encourage the research and development of virtual simulation experimental and practical training teaching software, realize the extension of the production line of enterprises to the teaching line of the school, and bring the real problems in the industrial frontier and enterprise practice into the teaching link. According to the characteristics of disciplines and specialties, select outstanding backbone teachers to carry out online and offline blended teaching "brand courses" and "star teachers" team construction, so as to enhance the adhesion and enthusiasm of students' online course learning. In-depth study of changes in the student population, fully explore the educational needs of future students, scientifically formulate evaluation standards based on data, strengthen process evaluation based on data, explore the development of stage evaluation of students' learning outcomes and the whole process evaluation of four-year university study, establish big data files and digital portraits of students' growth covering learning literacy, scientific literacy, digital literacy, etc., and realize the "one student, one family" principle. "Establish big data files and digital portraits covering learning literacy, scientific literacy, digital literacy and other aspects of students' growth, so as to realize the goal of personalized cultivation for thousands of students. Explore the establishment of a growth achievement system and incentive mechanism for teachers and students in online education, personalized teaching management and services for teachers in combination with the platform data information, and effective guarantee of online teaching quality.

### **COMPETING INTERESTS**

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# ANALYSIS OF LAND USE ISSUES IN THE PROCESS OF URBAN-**RURAL INTEGRATION**

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Abstract: As the transition zone between urban and rural areas, the urban fringe plays an important role in the infiltration of urban economy, culture and social concepts into the countryside. This area is not only the physical boundary between the city and the countryside, but also the intersection and integration of two different lifestyles and values. Therefore, how to realize the overall planning from land layout to socio-economic characteristics through careful land use planning is a subject of great research value. This study deeply discusses the mode of urban-rural interaction, analyzes the problems faced by land use in the process of urban-rural integration, and further explores the root causes of these problems. Based on these analyses, this study puts forward targeted countermeasures to provide scientific planning suggestions and policy support for the realization of urban-rural integration.

Keywords: Urban-rural interaction model; Dynamic land use; Urban-rural integration

### **1 INTRODUCTION**

In the process of urbanization, there is a common phenomenon in land use at home and abroad, that is, the process of urbanization is always accompanied by changes in land use patterns. In China, urbanization and its synergistic effects have driven the changes of land natural attributes, economic attributes, social attributes and ecological attributes in urban and rural areas, such as land supply and demand, land use spatial structure, land use functional structure, and land ownership relationship. Through the analysis of the impact of the suburbanization process of some cities on the land use in the urban suburbs (urban fringe), it can be seen that the dynamic succession of land use in the urban suburbs is the result of the interaction between urban and rural areas, and the non-agricultural development of land in the urban suburbs expands from the central city to the rural area, which is orderly and phased [1].

However, some scholars have two misunderstandings about China's urban-rural integration strategy: one is that urbanrural integration is to integrate urban and rural areas (even if rural areas become cities); the other is that urban-rural integration is the integration of industrial layout between urban and rural areas (that is, excessive development of rural economy). All these understandings have led to policy failure and serious waste of resources. In fact, the most fundamental goal of this strategy is to break through the institutional barriers and establish the mechanism of "industry supporting agriculture and cities supporting rural areas". The core content of this strategy is to strengthen the interaction between urban and rural areas. It is generally believed that the interaction between urban and rural areas is the flow of material, capital, manpower, information and technology between urban and rural areas. However, China has a vast territory, and there are obvious regional differences in the interaction between urban and rural areas. Therefore, urbanrural interaction shows different types in different regions, and needs different ways to express the types of urban-rural integration.

The main purposes of this article are as follows: (1) to analyze the dynamic land use of different types of urban-rural integration and urban-rural integration areas in China. (2) Propose various solutions to achieve urban-rural integration.

### 2 TYPES OF URBAN-RURAL INTERACTION PATTERNS AND CORRESPONDING DYNAMIC LAND **USE PATTERNS**

The urban-rural economic interaction mode refers to the dynamic balance process of gradually realizing the development of urban and rural areas on the basis of the overall improvement of urban and rural purchasing power by actively promoting the circulation of various elements such as human resources, markets, information, industry and culture between urban and rural areas to form a comprehensive communication, contact, exchange and mutual promotion mechanism between urban and rural areas in the process of economic and social development. In the process of urban-rural integration, cities and rural areas, as different types of economic subjects, will encounter a series of resource factors such as human resources, capital, land and so on, regardless of the emphasis on urban or rural development strategies. These problems must be effectively solved through the interaction between urban and rural areas. For this reason, this section analyzes the different types of development in the urban-rural interaction mode, summarizes the different land use modes, and finds out what constraints exist in the land use in the urban-rural interaction mode, in order to clarify the problems existing in the process of China's urban-rural integration and provide theoretical guidance for the implementation of the urban-rural integration strategy.

### 2.1 Types Of Urban Rural Interaction Modes

The goal of the coordinated development of urban and rural areas is to achieve the coordinated development of urban modernization, rural urbanization and urban-rural integration. The core issue is to deal with the problems of "people", "land" and "industry". Through the analysis, we can see that different urban-rural interaction patterns show different dynamic land use patterns. Among them, the urban-rural interaction mode mainly includes three types: urbanization peripheral areas, small towns and marginal areas in cities.

### 2.1.1 The periphery of urbanization in cities - suburbs

This type exists in the peripheral areas surrounding all cities. From an administrative perspective, the suburb refers to the area surrounding the urban built-up area, which may also encompass areas that need to be controlled for urban development, including both the inner and outer suburbs. In cities of varying sizes, the size and functions of suburbs differ. In large or megacities, due to the city-administers-county administrative system, the geographical scope of suburbs can be extensive, even encompassing several county seats and market towns. Meanwhile, the suburb constitutes a relatively stable administrative boundary. Any land use changes necessitated by development must undergo certain procedures, specifically, expanding the administrative boundaries of the city [2].

### 2.1.2 Small-town

China's urban development has always emphasized the integration of urban and rural areas, as well as the integration of industry and agriculture. Small towns, due to their crucial role in bridging urban and rural areas, are the most active in the urban network system. Economically prosperous small towns mainly consist of non-agricultural industries and a strong agricultural economy [3].

### 2.1.3 Fringe areas

Urban fringe refers to the city that relies on the development of labor force. From the perspective of spatial form and urban radiation, it describes the spatial state of urban land to rural land. It has no clear boundary of administrative delimitation, and has the characteristics of dynamic, transitional and complex. In addition, the urban fringe is a dynamic development zone with periodic fluctuation development law, which gradually evolves from the mixed state of urban and rural areas in the periphery of the city to the urban form, and has the trend of outward promotion in scope.

### 2.2 Land Use Type

According to the literature, the promotion of industrialization, urbanization and urbanization has gradually made the rural area transition to the urban land use mode. The hierarchical division and circle structure of land use of the three urban-rural interaction models are gradually reflected, that is, four types of residential, commercial, industrial and agricultural land are successively distributed from the center to the outside, and the four types are separated and cross arranged in the whole space.

# 2.2.1 Urbanization in cities land use in peripheral areas

The suburban area is the peripheral area close to the urban area. The land use type of the suburban area is mainly urban agriculture, mainly Horticulture (planting flowers, bonsai, etc.) and facility agriculture (greenhouse vegetables, greenhouse agriculture, etc.). At the same time, the city's industry, storage, external transportation, large green space, etc. are distributed. The outer suburbs are far away from the urban area, mainly producing grain and cash crops, or small towns with urban industry. Based on the proportion of output value and employees of the three industries, this paper analyzes the economic regional types of small towns in the suburbs of Beijing by comprehensively using the location quotient method and Nadal method, which has a very obvious spatial distribution characteristics of "core periphery", showing a diversified development trend. Small towns in the suburbs of Beijing can be divided into four types: urban agriculture driven type, manufacturing owner led type, service owner led type and balanced development type, accounting for 34%, 10%, 31% and 35% respectively [4].

### 2.2.2 Land use in small towns

The land use of small towns is mainly reflected in the diffusion base of urban industry, and it is also the spatial agglomeration center of rural industrialization and urbanization in the suburbs. Satellite cities or secondary cities are established here. The real estate development is mainly based on the development of land in blocks, and the development scale of various industrial parks (including township enterprise parks, municipal industrial parks, economic and technological development zones, and individual and private economic development zones) is relatively large [5].

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According to the summary, the urban-rural ecotone is located at the junction of the two "plates" of "city" and "countryside". Driven by the two forces of urban radiation and expansion and rural urbanization, land use change is the most sensitive. Through summarizing the process of urban-rural integration in China, the urban-rural interaction model mainly includes three types of urbanization peripheral areas, small towns and marginal areas in cities. From the perspective of land use mode, land use model can be divided into several types: suburban agricultural land vegetable land industrial land residential land commercial and service facilities supporting land. From the perspective of input

factors, land use is mainly labor capital intensive, capital technology intensive, structural intensive and ecological intensive. From the perspective of urban-rural interaction model, land use model and input factors, the types and functions of urban-rural land use are complementary to urban economic development and functions, and finally form different urban-rural interaction modes. However, in the process of urban-rural integration, in addition to the advantages of facilitating urban life, promoting urban-rural industrial development, and developing rural land use, there are also many land use problems, and the root causes of the problems are more complex. This paper makes a simple sorting and analysis, in order to find out the ways to solve the urban-rural integration, and provide theoretical guidance for the realization of urban-rural integration in China.

### **3 PROBLEMS OF LAND USE IN URBAN RURAL INTEGRATION**

Through the above analysis, it can be seen that in the process of urban-rural integration, the level of urban economic development and resource conditions determine the different land use patterns. How to solve the problems of land use and household registration system is of great significance to ensure the comprehensive, coordinated and sustainable development of economy and society and the process of urban-rural integration.

### 3.1 Occupation Of Arable Land

The urban fringe is the area with the most concentrated non-agricultural transfer of agricultural land, and it is also the area with the most intense competition in urban and rural land use and land speculation. China's urbanization is at a stage of rapid development, and the phenomenon of suburbanization has begun to appear. With the progress of suburbanization, the migration of population promotes the rapid development of the real estate industry, occupying a large amount of land, especially high-quality farmland [6].

### 3.2 Unreasonable Allocation Of Land Resources And Serious Waste Of Land

The land use types in the urban-rural fringe are complex and diverse, but different land use types cross and interfere with each other in layout. For example, new residential areas are adjacent to rural residential areas, enterprises and livestock breeding are often mixed, and commercial land is sandwiched in the middle of industry and mining, which not only causes a waste of land resources, but also makes urban and rural construction extremely uncoordinated. In addition, a large number of development zones generally have the phenomenon of "expropriation but not use", untimely development and utilization, large areas of land are idle and wasted, and land use efficiency is generally low. Due to the large scale of land acquisition in these development zones, the waste of land resources is also the most serious area. On the one hand, the relationship between man and land is very tense in the urban-rural fringe. On the other hand, there

are the phenomena of large construction land occupation, low building density, low plot ratio, and serious waste. Many units often have to build fences or wire mesh around the periphery of the acquired land due to the large area of land acquisition, high land acquisition costs and lack of funds for construction, resulting in serious waste of land resources [7].

### 3.3 Household Registration System

As China relaxed the control of household registration management on the free movement of rural population in 1984, a large number of rural people poured into the city. These floating population are mostly concentrated in the urban fringe for some reasons. There are differences between this part of the population and urban areas in terms of labor and employment, social welfare, children's education and other issues. The main reason is the restriction of household registration, which does not enjoy the same treatment, thus hindering the transition from the dual economy of urban and rural population integration to the unitary economy.

#### **4 ROOT CAUSE ANALYSIS OF PROBLEMS**

Based on the above analysis of the characteristics and problems of land use in the urban-rural fringe, it can be found that the rapid development of urbanization and the expansion of urban land use is the direct reason for the disorder of land use in the urban-rural fringe. The land use and management system can not keep up with the rapid development of urbanization, and the management efficiency is very backward. Before the use procedures of a parcel of land have been completed, its use mode has been changed several times [8]. However, the deeper reason for this phenomenon and contradiction is the dual system of urban-rural division in China.

### 4.1 Lack Of Land Resources

With a large population, land resources are scarce and non renewable, especially the scarcity of arable land is the basic national condition of China. China has a large amount of land in absolute terms. The total area of inland land is about 9.6 million square kilometers, ranking the third in the world, but the per capita possession is small. The per capita land area is about 12 mu, less than 1/3 of the world per capita level (40 mu). The expansion of cities and towns needs land resources as support. The expansion of regional transportation facilities in small towns and the improvement of rural

living environment due to the increase of farmers' income all require a lot of land. The location conditions and economic foundation of the suburbs of large and medium-sized cities and the urban-rural fringe are good, so the land occupied by their construction and expansion is mainly cultivated land with good topographic conditions and good soil quality.

### 4.2 Urban And Rural Economic Development And Population Growth

The development of cities, like the growth of urban and rural population, needs certain land support in the process of development and growth, and the expansion of built-up areas will continue to erode the surrounding agricultural land (mostly fertile farmland). It is necessary to develop cities and realize the dynamic balance of the total amount of cultivated land, so the contradiction between construction land and agricultural land is becoming increasingly prominent. [9] With the continuous increase of rural surplus labor force and its transfer to cities, towns and urban and rural areas, it is predicted that in the next 15 years, cities at all levels and all types of cities, including towns, will increase the urban population by about 16million-17million each year. However, the original big cities can no longer accommodate such a large number of new people. Therefore, there will be the problem of the occupation of cultivated land by urban construction, one-sided emphasis on "making money from land", ignoring the protection of cultivated land, and the phenomenon that farmers make money by selling land and arbitrarily occupy cultivated land. Excessive occupation of cultivated land seriously affects the sustainable development of agriculture [10].

### 4.3 The Land Use And Management System Cannot Keep Pace With The Rapid Development Of Urbanization

Different land systems in rural and urban areas are partly responsible for the separation of urban and rural dual structures. First of all, land ownership is different. Urban land is owned by the state, while rural land is collectively owned by farmers. Secondly, the land use system is different. The acquisition of urban land use right is mainly in the form of bidding, auction and listing. There are many forms of rural land use right transfer. To sum up, there are five basic forms, namely, shareholding, leasing, subcontracting, transfer and exchange, accounting for 35.9%, 29.5%, 23.4%, 3.0% and 2.6% respectively [11]. Third, the land management system is different. In 1986, China established a unified urban and rural land management system to effectively manage land. However, the relationship between urban and rural land has not been straightened out in terms of system. In order to develop and build cities, such means as seizing cultivated land should be adopted, so that rural land can be used as the "reserve force" of urban land at any time to change its nature.

### **5 COUNTERMEASURES AND SUGGESTIONS**

### 5.1 Choose A Reasonable Way Of Land Use

In the process of urban land use, we should strive to achieve the maximum degree of intensive and efficient use, and optimize the allocation of land resources in this way. Through such efforts, we can effectively save some land resources, thereby reducing the occupation of agricultural land. This practice not only helps to protect cultivated land resources, but also promotes the coordinated and sustainable development of urban and rural economy, and ensures the long-term stable growth of social economy.

In order to achieve this goal, the government and relevant departments need to formulate and implement a series of scientific and reasonable land management policies. These policies should encourage land users to adopt more economical and environmentally friendly land use methods, such as promoting high-rise buildings and multi-storey buildings, in order to reduce the plane expansion of land. At the same time, land use planning should be strengthened, and different functional areas such as industry, commerce and housing should be reasonably divided to avoid the waste of land resources.

### 5.2 Effective Urban And Rural Land Use Management

In the process of promoting urbanization, if the land use in rural areas is lack of rationality, it will directly lead to difficulties and challenges in urban land management. Therefore, in land management, we must adopt the strategy of unified management of urban and rural land to ensure that urban and rural land management can cooperate with each other and achieve effective cooperation. Although there is a distinction between urban and rural land management systems, which seems to be a division of labor on the surface, in fact, this division may lead to the disconnection between the two, which is not conducive to the balanced and healthy development of urban and rural areas.

In order to realize the unified management of urban and rural land, it is necessary to establish a comprehensive land management system, which should cover the planning, use, protection and supervision of urban and rural land. Through such a system, we can ensure the rational distribution and efficient use of land resources, while avoiding environmental problems and social contradictions caused by improper land use. In addition, the unified management of urban and rural land also requires a good communication and coordination mechanism between policy makers and implementers to ensure the consistency of policy and implementation.

### 5.3 Summarize The Urban And Rural Development Model

In the process of urban and rural planning and determining the scale of land use, it is essential to conduct in-depth analysis and Consideration Based on the local actual situation. This includes reasonably predicting the future population development trend, so as to accurately determine the scale of urban land. At the same time, it is necessary to conduct in-depth summary and Research on the urban and rural development model, so as to predict the urban and rural population and its change trend in the next few years as accurately as possible. Through these comprehensive analysis and prediction, we can formulate accurate and reasonable land use planning to meet the actual needs of urban and rural development.

In addition, urban and rural planners should also consider the principle of sustainable development to ensure that the planning scheme not only meets the current needs, but also leaves room for future development. In the planning process, environmental protection and resource conservation should be fully considered to avoid disorderly expansion and over development. At the same time, the planning should have a certain degree of flexibility, so that it can be adjusted when necessary to adapt to changes in socio-economic conditions. In addition, the planning should also focus on supporting public facilities to ensure the quality of life of residents and promote social harmony and stability.

### 5.4 Policy And System Guarantee

In the process of urban-rural integration, we must consider and solve a series of key issues in advance, which involve many policy areas, including but not limited to the household registration system, fiscal policy, tax policy and social welfare system. First of all, the reform of the household registration system is a crucial step. It will open the door for farmers to enter the city and start businesses, so that they can find new development opportunities in the city. Secondly, the reform of the rural financial system can not be ignored, which will ensure that farmers and rural enterprises can obtain the necessary loan support, so as to promote the development of agriculture and rural economy. In addition, the reform of labor employment and social security system is equally important. It will enable farmers to cross the boundaries between urban and rural areas, find jobs in cities, and enjoy the same social security treatment as urban residents. Finally, the reform of the fiscal and tax system will help to establish a more equitable and efficient public finance system. Only in this way can we effectively integrate urban and rural resources, achieve mutual benefit and win -win between urban and rural areas, and promote the balanced development of social economy.

### **COMPETING INTERESTS**

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

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