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Scientific and Social Research

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Sense of Place and Rural Tourism: A Systematic Review of Local Residents' Impacts

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Abstract: With the rapid development of tourist villages, the sense of place among local residents has increasingly influenced their development. In recent years, research on local residents' sense of place has gained prominence, necessitating a comprehensive literature review to enhance understanding in this area. This study employed systematic evaluation and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methods to examine relevant literature. Utilizing resources such as CNKI and AiritiLibrary, 28 papers were selected from 522 that met the study criteria. These papers were reviewed from three perspectives: physical environment factors, social environment factors, and personal factors. The findings of the study show that, firstly, the influence of a variety of factors is felt in the place of the local residents, including historical, cultural, socio-economic, and natural environmental aspects. These factors together shape the feelings and emotions of the local residents towards their hometown. Secondly, the sense of place is crucial to the identification, dependence, and emotional expression of communities and places. Understanding and stimulating the sense of place of local residents is conducive to the development and growth of local communities. This emotion and sense of identity can promote the sustainable development of local communities and support the development of tourism villages. Finally, a sense of place significantly impacts tourism development, including attitudes and support for tourism. This is crucial to the sustainable development of local communities and the successful development of tourism villages. The participation and support of local residents is vital to the prosperity of the tourism industry, as well as the protection and preservation of local cultural and natural resources. Taken together, the study of local residents' sense of place provides researchers with important insights into the development of tourism villages. These insights can help guide local policy making and the sustainable development of the tourism industry while emphasizing the critical role of local residents in shaping and supporting local development.

Keywords: Sense of place; Residents' sense of place; Tourism village; Systematic review

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1. Introduction

The trend of cultural globalization undoubtedly has a profound impact on our society, integrating cultural differences geographically and potentially becoming a dominant force in future cultures. This trend may lead to cultural hegemony in the future, as mentioned in a study ^[1]. This globalization trend is reflected in rural tourism as a rapid development of social constructivism. Since the 1990s, the theoretical perspective of social constructivism has emphasized the role of culture in the uniqueness of rural spaces, linking rural social-cultural structures with the natural environment at the forefront of rural research ^[2]. However, the social constructivism perspective also raises some issues, such as Murdoch mentioned that the social construction of rural space is increasingly detached from its geographical function ^[3]. Social constructivism may lead to rural areas, communities, and landscapes becoming detached from their original geographical functions, turning them into a type of surreal commodity ^[4]. Modern rural tourism development, to meet social needs, undergoes mass standardized construction, so rural lifestyles and cultures are ignored, causing an experience vacuum. This modern functionalism construction model has become a major means of environmental construction, inevitably leading to environmental and cultural confusion and bewilderment, causing rural tourism areas to gradually lose their vitality. This has a negative impact on the sense of place, leading to a lack of place-based landscape in tourist rural areas and exacerbating the crisis in the sense of place in human habitats, losing an important spiritual foundation of human habitat culture. Furthermore, this causes rural tourism areas to face issues such as declining environmental quality, damaged rural culture, homogeneous tourism competition, and overall poor quality ^[5]. This also prompts reflection; under the postmodern influence, people begin to rediscover local resources to face these modern challenges ^[6]. Therefore, the village is no longer just the traditional sense of a physical environment; rural lifestyles and culture, as an indispensable part of the village, are increasingly valued. Rural lifestyles and culture as part of the village have unique cultural and environmental values ^[7]. When developing tourist rural areas, the creation of a sense of place is indispensable, and as an embodiment of the relationship between people and the environment, further research and discussion on the sense of place are needed. This will provide new directions for thought and further explore the meaning of the sense of place. Global cultural integration may bring risks of cultural hegemony, but the perspective of the sense of place also offers a new viewpoint on tourist rural areas. Further research and discussion on the sense of place will better understand how culture, consumption, and tourism affect rural communities and culture.

In the current environment of prevalent consumerism, rural tourism, as a product, is consumed. Soja points out that consumption is not just a relationship between individuals and objects but also a response between individuals, collectives, and the world, a systemic activity and comprehensive response ^[1]. It is on this consumption system that the cultural system is established. Although rural tourism covers a wide range of tourism opportunities and practical experiences, it has long been recognized that the fundamental attraction of rural areas as tourist destinations lies in their unique local sense of place. Tourists are attracted to rural areas not only because of their physical attributes and intrinsic qualities but also because of the locality characteristics represented by the rural areas. This unique sense of place becomes increasingly precious against the backdrop of high urbanization; the cultural values of agrarian civilization's local sense of place can effectively counter the high standardization, formatting, and homogenization of modern society ^[8]. Research on the sense of place helps those involved in rural tourism understand the significance and value of rural cultural diversity, providing new directions for the future development of rural tourism, and providing a basis for maintaining the historical context of rural areas and sustainable development as tourist destinations.

When researching the sense of place, there are a series of complex contradictions and challenges. These contradictions reflect the complexity of the sense of place as a multidimensional concept as follows. The contradiction between mobility and locality: The sense of place has mobility, allowing outsiders to develop emotional connections with the place, and has locality, emphasizing the deep identification of locals with specific locations. This contradiction is often manifested as a distinction between local residents and foreign tourists, as they may feel very different about the same place. Due to the long-term stability of agrarian civilization, the rural social structure is also unusually stable, and rural societies on both sides of the strait are formed by a combination of kinship and regional relationships, forming relatively independent social living spaces ^[6]. Local residents play a dominant role in shaping the rural sense of place, but in the process of developing rural tourism, to meet the tourists' sense of place, it may be necessary to transform the local environment, which may also have a destructive impact on local culture ^[9]. The contradiction between diachronicity and immediacy: The sense of place can include long-term accumulated emotions, but also immediate emotional experiences. Long-term residents may form a deep diachronic sense of place, while tourists may develop an immediate sense of place in a short time. Current research focuses more on individual emotional experiences, especially on place attachment, which makes the study of the sense of place emphasize individual subjectivity, thereby neglecting the subjectivity of local residents. The contradiction between individual experience and collective consciousness: The sense of place reflects both an individual's emotional and cognitive attachment to a specific place and is influenced by collective culture, social identity, and local knowledge. In research, the focus may be on the cognitive aspects of the sense of place, emphasizing commonality, or on the emotional aspects, emphasizing individuality. Currently, research on the sense of place focuses on individuals' emotional responses to places, with their attachment and emotional responses becoming the main focus ^[10]. In particular, it is noteworthy that the personal emotions of long-term residents living in tourist rural areas are often overlooked under the economic dominance of rural tourism. However, these local residents' cognitive understanding of the sense of place is of obvious importance for the development of tourist rural areas. Therefore, future research needs to pay more attention to the subjectivity of local residents in the sense of place, to more comprehensively understand the multiple facets and complexity of the sense of place. At the same time, a systematic review of the sense of place research on both sides of the strait will help provide more references and guidance for future related research.

2. Literature review

2.1. Rural tourism

Rural tourism refers to tourists visiting rural or rural areas to experience local culture, customs, natural landscapes, and lifestyles. This form of tourism emphasizes the exploration of the uniqueness and authenticity of rural and rural areas, where tourists can participate in agricultural activities, taste local specialties, visit historical monuments, admire natural landscapes, and experience traditional crafts. Rural tourism has become an increasingly popular research field in human geography, reflecting people's growing interest in the development and economic diversification of rural areas. The concept of rural tourism includes a series of activities, including agricultural tourism, ecotourism, cultural tourism, and adventure tourism, all located in rural areas, emphasizing the unique natural and cultural features of these places. The development of rural tourism can generate some controversies, a key debate point being its contribution to the economic development of rural areas. Some

scholars believe that rural tourism can provide significant economic benefits to rural communities, such as creating income for local businesses and job opportunities for rural residents ^[11–12]. However, others have raised concerns about the potential negative impacts of rural tourism, such as the excessive commercialization of rural areas and the displacement of locals from their traditional lands and resources ^[13–14]. This form of tourism helps to raise the profile of rural areas, attract tourists, and inject vitality into the local economy, but it also needs to be managed carefully to prevent overdevelopment and the loss of cultural resources. The impact of rural tourism on local residents and culture is also controversial. Some scholars believe that rural tourism helps to protect and promote local culture, traditions, and lifestyles, thereby enhancing the sense of place and community in rural areas ^[15]. Some emphasize the need to balance the interests of tourists and local communities and ensure that the development of rural tourism does not lead to the commodification and caricature of local culture. Although rural tourism showcases the unique charm of rural areas, its impact and sustainability must be carefully considered and balanced during the development process.

People are increasingly concerned about the relationship between rural tourism and sustainable development, with some scholars arguing that by encouraging the protection of natural and cultural resources and promoting local economic development, rural tourism can provide a sustainable alternative to traditional forms of agriculture and resource extraction ^[16]. However, some are also concerned about the potential negative impacts of rural tourism on the environment and local communities, suggesting the need for more sustainable tourism practices ^[17–18]. Therefore, to achieve long-term sustainable development of rural tourism, a balance must be struck between community participation, cultural protection, and environmental sustainability. Overall, the concept of rural tourism has become an important research field in human geography, reflecting people's growing interest in the development and economic diversification of rural areas. Through extensive empirical and theoretical research, scholars deepen their understanding of the economic, cultural, and environmental impacts of rural tourism, and emphasize the need to develop more sustainable and inclusive forms of rural tourism.

2.2. Sense of place

The sense of place refers to the emotional, cognitive, and emotional attachment of individuals or communities to a specific geographical area or place. It reflects people's deep emotional connection to a place, usually including aspects related to the history, culture, social connections, and emotional memories of that area. The sense of place is a strong emotional experience that can arise when people interact with a specific location, thereby shaping their behavior and decision-making. In discussions of rural tourism, the sense of place plays an important role. It can explain why people are attracted to rural areas with unique local features, as these places trigger their emotions and emotional attachments. Consumer culture is also closely related to the sense of place, as people's consumption decisions are often influenced by the sense of place, and they may choose to support and protect products and services with local characteristics. It helps researchers understand the complex relationships between people and geographical spaces, cultures, and social connections, and how these influence their behavior and decisions. Since 1970, human geography scholars such as Tuan and Relph have reintroduced the term "place" into humanistic geography research ^[19–20]. The theoretical origin of the sense of place can be traced back to American geographer Yi-Fu Tuan, whose important work "Topophilia: A Study of Environmental Perception, Attitudes, and Values" explores the relationship between people and their physical environment and its impact on people ^[19]. In this book, Yi-Fu Tuan introduced the concept of "environmental

emotion” (topophilia), which refers to the emotional bond between people and their place of residence, and the sense of place is “people’s subjective and emotional attachment to a specific physical environment” ^[19]. The sense of place is rooted in people’s sensory experiences and perceptions of the surrounding world, and these perceptions are influenced by their cultural, social, and historical backgrounds.

Subsequently, the theory of the sense of place has been further developed and expanded by many scholars in human geography and related fields. For example, David Seamon’s “A Geography of the Lifeworld” and Edward Relph’s “Place and Placelessness” further developed Yi-Fu Tuan’s ideas and provided a more detailed analysis of how people experience and understand the surrounding world ^[20–21]. In recent years, the theory of place perception has been further developed and expanded, including a series of interdisciplinary perspectives. For example, feminist geographers have studied the impact of place perception in terms of gender, and cultural geographers have emphasized the importance of place in the generation and transmission of cultural meanings ^[22–23].

Tofflemire identified three basic dimensions of place: location, locale, and sense of place ^[24]. The first two refer to the physical environment of a place, while the latter reflects people’s subjective and emotional attachment to a place. Harvey believes that a place is not just a physical location, but is also shaped by power relations and social practices ^[25]. Casey argues that the sense of place is closely related to the identity and sense of belonging, shaped by personal experiences and cultural background ^[26]. Research on the sense of place explores the relationship between people and the environment from perspectives such as human perception, attitudes, and values, including deep experiences in specific places, often discussed in terms of tourist involvement, and emotional connections between people and specific places, often used to discuss the relationship between local residents and the environment.

The sense of place contains collective memory frameworks and forms in traditional rural areas on both sides of the strait, representing the rural Society society’s cultural structure formed through long-term exchanges and adjustments ^[27]. The sense of identity developed through long-term contact between people and the land is an important factor that can strengthen the connection between people and places. Some scholars have used dimensions such as place attachment, place identification, place dependence, institutional loyalty, satisfaction with the place, place image, sense of belonging, rootedness, sense of security, neighborly relationships, community emotions, environment and health, social connections, and adaptability to places to analyze the factors that influence the formation of the sense of place and the factors that affect it ^[28–29]. Researchers can interpret the sense of place from different angles to help them understand how people interact with their surroundings and are influenced by them. Overall, the theory of the sense of place has become a key research area in human geography, as well as an area of interest for scholars in other fields such as anthropology, psychology, and sociology. Through extensive empirical and theoretical research, scholars have gained a more comprehensive understanding of the relationships between people and their places of residence.

The sense of place plays an important role in influencing rural tourism. Rural tourism can promote the creation and protection of a sense of place by providing tourists with opportunities to interact with local cultures, traditions, and environments ^[30]. A strong sense of place can enhance the attractiveness and sustainability of rural destinations, shape tourist attitudes and behaviors, and promote positive relationships between rural communities and the tourism industry. When tourists can interact with local residents, learn about local history and traditions, and participate in local activities, they can cultivate a sense of attachment and connection to the destination, bringing positive experiences to tourists. When tourists develop a sense of attachment and emotional connection to a place, they are more likely to appreciate and respect the local

environment, culture, and community, and engage in responsible and sustainable tourism practices ^[31]. This contributes to the long-term sustainability of rural tourism, as tourists become advocates for protecting and maintaining the sense of place of rural destinations. The rapid growth of the tourism industry and the commodification of local resources for tourism purposes can lead to overcrowding, environmental degradation, conflicts between tourists and locals, and a loss of authenticity, thereby negatively affecting the sense of place in rural communities ^[32]. Therefore, careful management of rural tourism development is necessary to ensure that it enhances the sense of place while minimizing potential negative impacts.

2.3. Rural tourism and resident sense of place

In recent years, rural tourism, as an alternative form of tourism that promotes the economic development of rural areas, has received great attention, while providing tourists with opportunities to experience local culture and the environment ^[12]. A key concept discussed in the literature related to rural tourism is the sense of place, which refers to an individual's emotional and cognitive attachment to a specific location ^[20]. The sense of place is usually formed by the natural and cultural elements of the destination, as well as the social interactions that occur there ^[33].

Some studies have examined the relationship between rural tourism and the sense of place, emphasizing how rural tourism influences individuals' perceptions and experiences of the places they visit. Rural tourism promotes the formation of a sense of place by providing tourists with opportunities to interact with local residents, learn about local history and traditions, and participate in local activities. Similarly, a study conducted in Spain found that rural tourism, by providing authentic cultural experiences and promoting connections with the natural environment, helps to cultivate tourists' sense of place ^[34]. Additionally, rural tourism has been shown to help protect and promote local culture and traditions, which in turn can strengthen the sense of place in rural communities. Rural tourism plays an important role in restoring traditional practices such as agriculture, fishing, and handicrafts, which helps to maintain the cultural heritage of the area and create a sense of place for tourists and locals ^[35]. Rural tourism helps to strengthen the cultural identity of local communities by promoting traditional agricultural practices, cuisine, and crafts ^[31]. However, some scholars have also raised concerns about the potential negative impacts of rural tourism on the sense of place. Rapid growth in rural tourism can lead to overcrowding, environmental degradation, and conflicts between tourists and locals, thereby negatively affecting the sense of place in rural communities ^[36]. The commodification of local culture and the environment for tourism purposes can lead to a loss of authenticity and a dilution of the sense of place ^[32].

The literature indicates that rural tourism can have both positive and negative impacts on the sense of place. On the one hand, rural tourism can provide tourists with opportunities to access local culture, traditions, and environments, thereby helping to create and protect a sense of place. On the other hand, the rapid growth of the tourism industry and the commodification of local resources can pose challenges and potentially weaken the sense of belonging in rural communities. Further research is needed to better understand the complex and dynamic relationship between rural tourism and the sense of place and to develop sustainable rural tourism development strategies that enhance the sense of place while minimizing negative impacts.

2.4. Resident sense of place

In past research on the sense of place, Shamai classified the sense of place into seven levels based on emotions and behaviors: no sense of place, knowing you are in a place, belonging to a place, being attached to a place,

identifying with the goals of a place, participating in a place, and sacrificing for a place^[37]. Steel divided environmental factors into natural and social environments, both of which interact with individuals to form a sense of place^[38]. Based on this, he constructed a sense of place composed of the physical setting, social setting, and psychological factors.

The sense of place refers to people's attachment and connection to a specific location, which is often formed by their experiences and perceptions of the physical environment. Many studies have explored the relationship between physical environmental factors and the sense of place. Natural features such as mountains, rivers, and forests can evoke strong emotional responses and contribute to the formation of a sense of place^[19, 39]. Proximity to water can increase residents' sense of place attachment, social capital, and community identification^[40]. Similarly, urban environments can also affect the sense of place, with factors such as architecture, public art, and landmarks also playing a role^[21]. The design of public spaces in residential environments can affect residents' attachment to and identification with the local community^[41]. Another important aspect of the relationship between physical environmental factors and the sense of place is the impact of environmental degradation and loss. Studies have shown that physical environmental changes, such as deforestation, urbanization, and pollution, can erode the sense of place, leading to a sense of community fragmentation and loss^[42–43]. Exposure to environmental hazards can increase stress and anxiety levels, reduce residents' attachment to the local community, and lead to social disintegration^[44]. Physical environmental factors can have a significant impact on the sense of place among local residents, affecting access to natural resources, exposure to environmental hazards, and the design of the built environment, all of which can shape residents' attachment to the local community and promote a sense of belonging.

Social interactions and community dynamics can greatly influence the sense of place among local residents^[45–46]. The presence of social networks and community organizations, as well as shared cultural customs and traditions, can promote a sense of belonging and attachment to a specific place. Individuals from different demographic groups may have different perceptions and experiences of a place and may assign different meanings and values to it^[47–48]. Another important aspect of the relationship between social environmental factors and the sense of place is the impact of social changes and conflicts. Studies have shown that changes in the social and cultural structure of a community, such as urbanization, displacement, or the influx of new residents, can erode the sense of place, leading to community fragmentation and a sense of loss^[49–50]. Culture is a pattern followed by a community or tribe, and the standardized beliefs and actions followed by the community are reflected in society. Simmel believed that everyday life must be seen as reflecting the overall nature of society from within^[51]. Everyday life, as a form of culture, along with politics and economics, shapes our lifeworld^[52]. The social relationships contained in everyday life, when linked to space, become a central perspective in the production of space. The everyday life, while producing space, also shapes the sense of place. Everyday life, as an important carrier of the sense of place, also promotes the development of the sense of place.

Personal emotions and emotional experiences can greatly influence their sense of place. People may attach positive or negative emotions to a specific location, which can affect their level of attachment and connection to that place^[53–54]. Similarly, cognitive factors, such as perception, cognition, and memory, can also play a role in shaping the sense of place. Studies have shown that people's perceptions and thoughts about a specific place can affect their attachment and connection to it^[42, 55]. Additionally, memories associated with a specific location can also shape people's attachment and connection to it. Another important aspect of the relationship between psychological factors and the sense of place is the impact of place identity. Place identity refers to the

way people define their relationship with a specific location and the social and cultural meanings associated with that place ^[47]. Studies have shown that a strong sense of place identity can promote a strong attachment and connection to a specific place, and personal experiences and memories can also affect this attachment and connection ^[56].

The traditional rural societies on both sides of the strait allow individual emotions to be more closely integrated with the environmental and social context. Nostalgia can significantly influence people's sense of belonging to their hometown and promote the formation of a sense of belonging ^[57]. People's perceptions and thoughts about a specific location can affect their sense of belonging and connection to that place ^[58].

In addition to these broad themes, many other psychological factors can shape the sense of place, including cultural identity, social norms, and individual differences in perception and cognition. For example, studies have shown that cultural identity on both sides of the strait is closely related to a sense of belonging and connection to specific places ^[59]. Social norms and cultural practices, such as ancestor worship traditions, can also affect people's emotional connections and sense of belonging to a specific place ^[60]. In empirical research on the sense of place, the factors influencing the sense of place are also classified according to personal factors, physical environmental factors, and social environmental factors ^[29]. In recent years, empirical research on the sense of place has shifted from traditional communities to leisure tourism, rural settlements, and other places ^[28]. In research on residents' sense of place, Zhang classified the factors influencing residents' sense of place as the socio-economic and cultural background of the person; the functional aspects of the place, providing a safe dwelling and shelter; the structure of social networks between people and society ^[61]. This study will use the classification method of personal, physical environmental, and social environmental factors influencing the sense of place based on previous research (See Table 1 for details).

Table 1. Sense of place influencing factors (Source: Collated from this study)

Physical environment	Unique natural environments, locality-specific characteristics, historical and cultural aspects, proximity and distance, environmental conditions, infrastructure and services, public spaces, indigenous residents, and architectural styles.
Physical and social environmental factors	Social connections, socioeconomic status, welfare and health, participation in activities, government administration, the use of social media, religious beliefs, festivals, celebrations, folklore, and the transmission of stories.
Personal factors	Gender, age, occupation, birthplace, duration of residence or stay, local experiences, family status, race, ethnicity, educational background, motivations, interests, hobbies, lifestyle, expectations, emotions, etc.

3. Research methodology

The literature review method adopted in this study is designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol. this method has been proven to be particularly suitable for literature reviews in human geography and has been widely used in studies related to the sense of place ^[62–64]. Therefore, this paper employs the PRISMA method to systematically review current articles related to the sense of place among rural residents in tourist areas, following these specific steps: (1) searching for topic-related articles, (2) filtering and including articles that meet eligibility criteria, (3) specifically analyzing the content and results of the selected articles.

To understand the latest research status and related literature on the sense of place among rural residents in tourist areas, this project systematically searched “CNKI” and “Airiti Library,” using the keywords “sense

of place” and “residents’ sense of place” in combination with “tourism rural.” The search was not restricted by publication year to ensure comprehensive data retrieval. The initial search yielded 522 articles. After reviewing the titles and abstracts for relevance, 162 unrelated articles were excluded. The review then narrowed down to 360 articles relevant to the research topic (CNKI 256, Airiti Library 104), and further scrutiny based on titles and research abstracts excluded 235 articles, leaving 28 articles (CNKI 16, Airiti Library 12) for a systematic review. This study will further analyze these articles to synthesize factors influencing residents’ sense of place, focusing on trends in sense of place research and the mutual influence between rural residents’ sense of place and tourism, thereby exploring potential research areas and directions for future studies across different regions.

3.1. Research analysis

The 28 articles were reviewed, categorized into three attributes based on different focuses identified by researchers, and grounded in various theoretical foundations. Most studies emphasizing the impact of the environment on humans or the support for environmental development utilized environmental psychology. Discussions on the effects on residents and their well-being often employed social psychology theories. Researchers commonly used social exchange theory to explore rural residents’ attitudes towards tourism development, but also employed theories like media geography, migration, and diaspora theory, with only one article using humanistic geography by scholar Yi-Fu Tuan as the theoretical starting point, enriching the research field of residents’ sense of place through life course frameworks.

Reviewing the focus of the 28 articles, 12 dealt with physical environmental factors, 13 with social environmental factors, and 3 with personal factors. The main theme was empirical research on rural residents’ sense of place, focusing on cognitive aspects and support variables related to tourism. Research on factors affecting the sense of place primarily examined the physical and socio-cultural environment of tourist areas, revealing a deep linkage between residents’ emotions and local tourism development. Future research should focus on everyday human life, exploring the interactions between people and places that generate a sense of place.

Research on residents’ sense of place commonly used quantitative methods, suitable for studying attitudes, emotions, and behaviors, with fewer qualitative studies. However, the role of quantitative research methods in the sense of place studies is significant. In recent years, mixed-methods research has gained recognition among scholars, offering a balanced approach and providing more scientific and meaningful conclusions for future research ^[65–66].

Researchers frequently use social exchange theory to discuss rural residents’ attitudes toward tourism development ^[67–68]. Social exchange theory, a utilitarian action model, often overlooks the role of culture. However, domestic rural tourism primarily focuses on cultural experiences, indicating that social exchange theory may not be entirely applicable. Researchers should carefully assess the applicability of Western theoretical models and consider developing theories that fit their specific contexts.

Although the research timeframe was not strictly limited, there has been a noticeable increase in the number of papers retrieved in the last two years. However, these studies have not fully focused on local residents, providing only a superficial understanding. The main research emphasis seems to be on the development of the tourism industry rather than an in-depth exploration of the roles and impacts of local residents. Additionally, these studies tend to analyze the impact of the environment on individuals, treating tourism development as a starting point but lacking in-depth studies on residents’ impacts on the environment.

In terms of research topics, whether in mainland China or Taiwan region, the focus has been on residents' sense of place, place attachment, and attitudes towards tourism development, indicating that a rural sense of place is a common area of interest. Both regions used quantitative and qualitative research methods, including surveys, in-depth interviews, and observations, helping to fully understand residents' sense of place. Factors influencing the sense of place, such as lifestyle, religious activities, festival events, and tourism development, were examined in these studies. The academic fields involved include psychology, social psychology, and environmental psychology, exploring residents' emotions, attitudes, and behaviors.

However, there are differences between the two regions, primarily due to different policy backgrounds, and social, and economic differences, which affect residents' feelings and attitudes towards places. For example, local government tourism policies may vary between the two regions, influencing residents' views on tourism development. Additionally, differences in study subjects were noted, as research in Taiwan seemed more focused on specific community groups, such as indigenous people, while research in mainland China covered a broader range of rural areas and residents. Despite regional and thematic differences, these studies collectively explored an important and complex topic—the cognition and experience of rural residents' sense of place. Through combined discussions, a better understanding of the multidimensionality of rural sense of place can be achieved, facilitating exchange and cooperation among researchers in various regions. This will also help provide a more comprehensive and in-depth perspective for future research.

3.2. Physical environmental factors

The sense of place is closely related to the spatial concepts in human geography. It represents the emotional and identity experience of an individual or community towards a specific geographical space. This sense is not only about personal emotions but is also closely related to the culture, history, and environmental factors of specific locations. The sense of place plays a significant role in social space as it can affect the emotions, identity, and behavior of individuals within that space. The presence of a sense of place can shape the characteristics of social spaces, such as community cohesion, cultural activities, and social networks. The sense of place is subjective and shaped by the social and cultural customs occurring within the space, where people create meanings through their daily activities and interactions (See **Table 2** for details).

Table 2. Physical environment impact (Data source: Compiled by this study)

Author(s)	Title	Essentials	Theoretical foundations	Research methods
Deng ZT, Mao Y, Liang B. (2013) ^[69]	Residents' Willingness to Participate in the Conservation of Historical and Cultural Towns—Data from Xindian Town in Hubei Province.	Discusses residents' perspectives on participation in the conservation of historical and cultural towns and offers strategies for conservation and sustainable development.	Environmental psychology	Quantitative research
Yin LJ, Zhang J, Han GS, Zhong S, Li Q (2012). ^[70]	Study on Rural Residents' Perceptions of Tourism Impacts from the Perspective of Sense of Place—Case of Tiantangzhai in Anhui Province.	Develops a theoretical model with developmental expectations as a mediating variable, to understand local residents' sense of place and perceptions of tourism impacts.	Environmental psychology	Quantitative research
He J (2021) ^[71]	Study on Local Residents' Sense of Place in Tourism Villages from a Spatial Mediation Perspective.	Focuses on space as a medium in daily life and explores its impact on local residents' emotions.	Media geography	Qualitative research

Table 1 (Continued)

Author(s)	Title	Essentials	Theoretical foundations	Research methods
Chen YF, Xu LJ (2013) ^[72]	Study on the Change of Sense of Place Among Residents of the Dai Ethnic Community in Xishuangbanna.	Conducts surveys to understand changes in local residents' identification with their living environment and their awareness of village structure and landscape due to new residents.	Environmental psychology	Quantitative research
Zhang CS, Li GZ (2019) ^[73]	Emotional Bonds of Islanders—Case Study of Wang'an Township.	Explores the interaction between islanders' sense of place and nature reserves from emotional and spatial perspectives.	Environmental psychology	Qualitative research
Zhong ZW, Chen JW, Chen BK, Zhu JT (2012) ^[74]	The Impact of Residents' Local Knowledge, Sense of Well-being, and Place Attachment on Tourism Development	Finding a strong positive relationship between residents' sense of well-being and place attachment	Environmental psychology	Quantitative research
Hua HL, Zhou SY, Jiao YM, Wang M, Hu ZX (2016) ^[75]	The Relationship Between Local Sense and Attitude Towards Terrace Conservation Among Residents of the Hani Terrace Heritage Site.	This study analyzes the relationship between the sense of place of heritage site residents and their connections to nature, society, and terrace conservation. The results indicate that a sense of place has a positive impact on people's attitudes towards ecological and environmental conservation.	Environmental psychology	Quantitative research
Tang Y, Zhong ML, Wang YS, Qin HY, Fu YY (2020) ^[76]	Cluster Analysis of Community Residents' Sense of Place in Dark Tourism Sites of Wenchuan Earthquake.	This study conducts a questionnaire survey among residents to understand their similar and distinctive characteristics based on dimensions of sense of place, to construct the dimensions of sense of place in dark tourism sites.	Environmental psychology	Quantitative research
Zhong BC (2017) ^[77]	A Study on the Perception of Tourism Impact through Local Residents' Place Attachment.	The author focuses on the residents of Shengkeng Old Street, using different emotional measurement methods to understand that the residents' place attachment shows a significant positive correlation with their perception of tourism impact.	Environmental psychology	Quantitative research
Yu ZY, Zhao XH, Liang CM (2020) ^[78]	Study on the Generation of Place Attachment among Residents of Ethnic Villages from the Perspective of Community Tourism Participation.	The research analyzes the issue of place attachment among residents of ethnic tourism villages from the perspective of community tourism participation, finding that villagers gain a strong sense of place during the process. Environmental Psychology. Qualitative Study.	Environmental psychology	Qualitative research
Yang HZ, Chen HZ, Feng BY (2014) ^[65]	A Study on the Attitudes of Residents in Miaoli's Hwangkeng Area towards Tourism Development.	This research explores quantitatively and qualitatively the residents' sense of place regarding the mines, further understanding the impact of tourism on the lives of local people and their attitudes towards tourism development.	Environmental psychology	Quantitative research Qualitative research
Chen JY (2020) ^[68]	The Relationship among Local Attachment, Well-being, and Attitudes towards Tourism Development of Island Residents: A Case Study of Kinmen.	This study uses surveys to understand that stronger local attachment among island residents indirectly enhances well-being, but has no positive correlation with attitudes towards tourism development.	Environmental Psychology	Quantitative research

Sense of place is not merely a physical or spatial concept but is deeply rooted in social and cultural factors. Therefore, analyzing the sense of place from a social perspective is important as it helps researchers understand how people's social experiences and interactions shape their perception and attachment to specific locations. Social factors have a profound impact on the sense of place of people on both sides of the Taiwan Strait, and it is essential to consider the cultural, historical, and socio-economic background of the local people to better preserve the local sense of place (See **Table 3** for details).

Table 3. Social environmental factors (Data source: Compiled by this study)

Author(s)	Title	Essentials	Theoretical foundations	Research methods
Zhong ZW, Lin JR, Huang Z ^[79]	A Study on the Relationship among Residents' Sense of Place, Festival Impact and Attitude Toward Festival Development with Residents' Differences in Different Districts as Moderating Variables	By studying the impact of residents' sense of place on the development of festivals and their attitudes toward the development of festivals, we explored residents' perceptions of festivals.	Social psychology	Quantitative research
Huang ZC, Weng YQ, Guo BC (2007) ^[80]	Attitudes of Indigenous Peoples in High-Altitude Mountain Areas toward Eco-tourism and National Land Restoration Policies: A Case Study of the Pi Mountain Area	Using the promotion of national land restoration policy as a starting point, the study aims to understand the level of support for eco-tourism and the attitude of the residents towards national land restoration policy.	Social psychology	Quantitative research
Zhang LH, Huang ZJ, Yang L (2016) ^[81]	Impact of Religious Activities on Residents' Sense of Local Attachment	By understanding the degree of involvement in the religious activities of Jinmen residents in welcoming the city god and the resulting sense of well-being, and whether a sense of local attachment is generated, we try to deduce the relationship between the degree of involvement in the activities, the sense of well-being, and the sense of local attachment of the residents.	Social psychology	Quantitative research
Zeng LS (2011) ^[82]	A Study on Local Residents' Perceptions of the Benefits of Festivals and Their Perceptions of Support for Festivals: A Case Study of Fung Lai Cultural Season.	The researcher used the "Benefit Recognition Scale", "Identification Scale" and "Support Scale" to investigate the local residents' identification with and support for the cultural season activities.	Social psychology	Quantitative research
Zhao XH (2019) ^[83]	A Study on the Mechanism of Sense of Place Formation of Residents in Community-Oriented Tourism Villages	The study was conducted through in-depth interviews with local residents to understand the formation and shaping of the residents' sense of place through tourism development after the local residents had participated in the development of tourism.	Social psychology	Qualitative research
Huang LM, Xian FJ (2021) ^[84]	Mechanism of the Influence of Residents' Sense of Place on Their Willingness to Support the Development of Red Tourism: The Mediating Role of Residents' Attitudes toward the Influence of the Tourism Industry	The study examines the mechanism of the residents' sense of place on their willingness to support tourism. When the exchange of resources is balanced, or when the host receives a higher benefit from the imbalance, the residents' influence on tourism is positive.	Social exchange theory	Quantitative research

Table 3 (Continued)

Author(s)	Title	Essentials	Theoretical foundations	Research methods
Chen SW, Zhao HL, Li W, Li DZ, Li MR (2020) ^[85]	Influence of Sense of Place of Residents in Northwest Alpine Ethnic Areas on the Support of Tourism Development--The Case of Xiahe County in Gannan Tibetan Autonomous Prefecture	A theoretical model was developed to understand the relationship between a sense of place and support for tourism development, whereby local residents' perception of benefits from tourism activities is significantly enhanced, leading to a welcoming attitude towards tourism development.	Social exchange theory	Quantitative research
Wang DG, Wang JL, Chen T, Zhang Y (2020) ^[86]	Modeling and Mechanisms of Rural Residents' Tourism Support — A Comparison of Tourist Villages in Suzhou Based on Different Life Cycle Stages	By constructing a structural relationship model of resident support in tourist destinations, the influence mechanism of resident support in tourist destinations at different life cycle stages was investigated.	Social psychology	Qualitative research
Yang YY, Wang YH (2016) ^[87]	The Impact of Rural Family Tourism on Residents' Sense of Place--A Case Study of Jiufeng Village in Pengzhou, Sichuan Province	The study explores the sense of place from the perspective of local practitioners in four dimensions: environmental, institutional, social, and emotional.	Social psychology	Qualitative research
Xu MJ, Wang RY, Liu Y, Wu HM ^[88]	A Study of Scale Preferences and Influential Factors on Residents' Sense of Place	Through quantitative and qualitative arguments and discussions on the scales of students' sense of place in their places of residence, the researcher aims to understand the relationship between the mechanisms of sense of place formation and the scales of residents' sense of place preferences.	Social psychology	Qualitative research
Guo BX ^[89]	Dependent or Severed Local Experiences? A Study of Local Identity in the Baozangyan Settlement of Taipei City	Participatory observation is utilized to understand the relationship between local people and places. People's awareness of and connection to the environment, and the influence of the local environment on the construction of people's sense of place.	Social psychology	Qualitative research
Lin GW (2020) ^[90]	Study on "Sense of Place" of Residents of Tourism-driven Traditional Villages in the Hexi Corridor: A Comparative Analysis of Peri-urban and Scenic Peri-urban Types	A study of the general characteristics and differences in the sense of place of tourists in tourism-driven traditional villages.	Social psychology	Qualitative research
Zhang CY (2014) ^[91]	A Study of Lifestyle Migration: Residents' Self-identification and Sense of Place in Miaoli's "Sanyi Art Village".	The study aims to understand the new immigrants' experience of urban-rural migration, their self-identity, and the impact of their lifestyle on the sense of place in the place of relocation.	Migration and dispersion theory	Qualitative research

Place attachment refers to an individual's sense of belonging and emotional attachment to a residential area, while the social environment encompasses numerous factors such as festival impacts, ecotourism policies, religious activities, festival event benefits, red tourism development, support for tourism development, the operational status of tourism villages, scale preferences, local experiences, and so on. These studies indicate that social environmental factors significantly affect residents' sense of place. For example, the perceived benefits of festival activities and a sense of

identity affect residents' support for festival activities ^[82]; ecotourism policies impact residents' attitudes and support for the tourism industry ^[80]; involvement in religious activities influences residents' place attachment ^[81]; the operational status of tourism villages affects residents' sense of place ^[84]; and local experiences affect residents' identification with their residential area ^[89]. This demonstrates that sense of place is not just an individual emotion, as it is also influenced by factors such as social environment and cultural background. For instance, cultural activities like tourism and festivals not only strengthen people's identification with their locale but also promote community cohesion and unity, enhancing residents' support for the area. Furthermore, factors like religion, lifestyle, and policies can also impact residents' sense of place. Religious beliefs can affect people's emotional identification with their locale and have a significant impact on social and cultural values. Understanding the influence of religious beliefs on the sense of place helps people better comprehend social and cultural diversity and complexity, thereby affecting residents' attitudes and support for the area. These findings reveal that the factors influencing the sense of place in the social environment are diverse, but their impact is generally positive, enhancing residents' sense of belonging and identification.

In summary, these studies provide researchers with a deep understanding of the relationship between residents' sense of place and social environmental factors. It is important to note that these studies are not isolated; they can corroborate, complement, and expand one another. For example, understanding residents' sense of place is crucial for promoting tourism development, improving residents' quality of life, and protecting the environment. In addition, these studies contribute to a deeper understanding of the mechanisms of place attachment formation, influencing factors, and how to enhance sense of place. The findings can serve as references for relevant departments and businesses to better understand residents' attitudes and behaviors toward the social environment and to formulate corresponding policies and measures to improve residents' quality of life and satisfaction, thereby promoting community development and social stability.

3.3. Personal emotional factors

Sense of place is a profound personal and emotional experience shaped by individual experiences and perceptions. By analyzing the sense of place from a personal emotional perspective, researchers can deeply understand how people's emotional attachments to specific locations influence their behavior, attitudes, and decisions (See **Table 4** for details).

Table 4. Personal factors (Data source: Compiled by this study)

Author(s)	Title	Essentials	Theoretical foundations	Research methods
Li HE (2017) ^[92]	A Study on the Sense of Place of Rural Out-migrant Youth and Young Adults in the Progress of Tourism Development—Based on the Perspective of Individual Life History	By sorting out the cognition, emotion, and behavioral intention of migrant youths toward their hometowns at different stages of tourism development, researchers can understand the trajectory of the change in people's sense of place brought about by the development of tourism for migrant youths while reconstructing the space of the countryside.	Phenomenal sociology	Qualitative research
Huang JF (2007) ^[93]	The Daily Life of Little Liuqiu Residents and the Shaping of a Sense of Place	The study focuses on how the fishery production and daily life of local residents shape the sense of place and the impact on religious identity.	Humanistic geography	Qualitative research
Zhang CS, Li GZ ^[94]	Emotional Bonding of Islanders — Take Wangan Township as an example.	Sense of Place Bridging Nature Reserves explores the interaction between islanders and sense of place islands from both emotional and spatial perspectives.	Environmental psychology	Qualitative research

Emotional factors play a crucial role in shaping a sense of place, where nostalgia, pride, and happiness are closely linked to people's emotional connections and sense of belonging to their hometowns ^[95]. The personal emotional dimension focuses on studying people's emotional identification and perception of place across different social backgrounds. Li's research, from the perspective of personal life history, explores the changes and reasons behind the sense of place among rural youth and middle-aged people during the development of tourism. The findings suggest that tourism development impacts the local sense of place to varying degrees, but these changes are not entirely negative, as tourism development also brings positive effects on economic development and cultural heritage. For young people who still live in their hometowns, their sense of place is more based on their identification with and understanding of the local history, culture, and social relationships. Huang focuses on the everyday life of residents of Xiao Liuqiu and the shaping of their sense of place, finding through interviews and observations that residents' sense of place is often closely related to their daily lives, such as their lifestyle, beliefs, and values ^[93]. Thus, for these residents, a sense of place is a deep cultural identification and emotional connection, influenced by family traditions, religious beliefs, and other factors. Zhang and Li's study, using Wang'an Township as an example, explores the emotional ties of islanders to their hometown ^[94-96]. The study reveals that islanders' sense of emotional identification with their hometown is multifaceted, encompassing their lifestyle, cultural traditions, and historical memories, as well as their recognition and feelings towards the natural environment of the island. This emotional connection is not only a personal emotion but also a social collective emotional identification, as it can bring together collective identification and a sense of belonging. Overall, these three papers explore the personal emotional aspects of a sense of place, discussing people's emotional identification and perception of place in different social contexts. These research findings help researchers better understand people's emotional identification with places, thus providing a vital theoretical and practical basis for the protection and sustainable development of local cultures.

4. Research discussion

The papers discuss the sense of place among residents in different cultural and social contexts, including aspects of travel development, festival activities, religion, ecotourism, red tourism, and traditional villages. These discussions address how the residents' sense of place is shaped and their attitudes towards tourism development. Some studies also differentiate between types of place attachment, such as attachment and identification. The research shows that residents' feelings and identities towards places are influenced by various factors, including history, culture, socioeconomic status, and natural environments. For example, some papers explore how residents' lifestyles, personal experiences, and cultural backgrounds affect their sense of place, as studied by Li Haie. Other studies investigate the relationship between a sense of place and activities such as tourism and festivals, as researched by Zhong Zhengwei et al. Further studies focus on specific areas such as religion, ecotourism, and red tourism, as examined by Zhang Lihui and Huang Zhengcong. These studies indicate that the formation, influencing factors, scale preferences, and attitudes towards tourism development vary among residents, as does their emotional and identity connection to places.

Synthesizing these findings, we can conclude that the sense of place among residents is a complex concept influenced by various factors, including individual life experiences, cultural backgrounds, family, and social relationships. The impact of different contexts and tourism development also affects residents' sense of place. An individual's sense of place is not just an emotional experience but also a cognitive and meaning-making

process. The sense of place continuously forms, transforms, and reconstructs throughout an individual's life course. In rural areas, the sense of place among the youth is often more susceptible to the impacts of tourism development than among the elderly. Residents' sense of place also influences tourism development, such as attitudes and support for the tourism industry. It is an important factor to consider in tourism development, which should respect and take into account the local residents' sense of place and identity. The sense of place is not a static concept but dynamically changes and reconstructs throughout the life course. Thus, for rural tourism development, it is crucial to consider residents' sense of place, respect their culture and lifestyle, and focus on understanding and responding to local residents' opinions and needs through communication and negotiation to establish a symbiotic and win-win relationship for sustainable development.

5. Conclusion

In summary, the sense of place among local residents plays a key role in the development of rural tourism. First, the sense of place among local residents is one of the important factors in rural tourism development. They have deep feelings for their homeland and culture, which can inspire their active participation in rural tourism development. Secondly, their participation and support are crucial for the sustainable development of rural tourism, as they have a profound understanding of the place, thus providing valuable advice and opinions. Finally, the identification with their sense of place also affects the quality and image of rural tourism, with their attitudes and behaviors significantly impacting tourists' impressions and experiences. Researchers often overlook the influence of residents on the sense of place and their role in daily life in rural development. The study of the sense of place requires more dimensions to fully understand its impact. Each resident's personal life experience is crucial in forming and maintaining a sense of place, hence the need for close attention to their opinions and needs, and establishing effective communication mechanisms to foster their participation and support.

However, research on rural tourism residents' sense of place is still lacking, with researchers often neglecting the impact of residents' sense of place perception and their daily life roles in rural development. The basis of place sense is the dynamic relationship between individuals and their social environment. It is a composite of emotions, social identity, cultural traditions, and social interactions, not only reflecting an individual's emotional experience of place but also the profound connections between society and place. When studying a group with complex social relationships, it is necessary to observe and research place sense from multiple perspectives to make the study more comprehensive. Each resident's personal life experience subjectively influences their everyday environment, providing ongoing vitality to place perception, and keeping rural tourism vibrant and not forgotten by time. Therefore, it is crucial to closely monitor local residents' opinions and needs, establish effective communication mechanisms, and encourage their participation and support. Planners and managers of rural tourism should establish effective resident participation mechanisms, encouraging their involvement in decision-making and project formulation. Protecting and maintaining place perception is key to sustainable tourism development. Managers of rural tourism should ensure that tourism activities do not damage the local culture and environment, maintaining the continuity of place perception. Future research should delve deeper into how residents' subjective emotions affect their attitudes and behaviors toward their daily living environment. Place perception includes not only emotions but also identification and connections. Therefore, future research could focus more on these dimensions to fully understand the role of place perception in rural tourism development. Planners and managers of rural tourism should establish

effective resident participation mechanisms, encouraging their involvement in decision-making and project formulation. Protecting and maintaining place perception is key to sustainable tourism development. Managers of rural tourism should ensure that tourism activities do not damage the local culture and environment, maintaining the continuity of place perception.

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Spatiotemporal Distribution Characteristics of Global Coarse-Mode Aerosol Optical Depth from 2012 to 2021

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Abstract: Aerosols, as suspended solid and liquid particles in the atmosphere, play a significant role in global climate change and environmental quality. This study utilizes global coarse-mode aerosol optical depth (CAOD) data from 2012 to 2021, derived through a deep learning model, to comprehensively analyze the spatiotemporal distribution characteristics of coarse-mode aerosols. The findings reveal that global CAOD values exhibit a fluctuating downward trend during the study period, with a more pronounced decline in the Northern Hemisphere, likely due to regional variations in climate change, desertification, and human activities. Spatially, regions such as North Africa, the Middle East, and parts of Asia show higher CAOD values, associated with desert dust activity and anthropogenic emissions, whereas regions like South America, Australia, and Antarctica have lower CAOD values, attributed to their cleaner atmospheric conditions and minimal human activity. The complex CAOD variations in the mid-latitudes of the Northern Hemisphere are influenced by climatic conditions, topographical features, and the distribution of human activities. This study provides critical data for understanding the role of coarse-mode aerosols in global climate change and highlights the importance of considering geographical differences in aerosol distribution in climate change research. The study offers a scientific basis for formulating environmental policies and interventions. Future research will further explore the specific contributions of aerosol sources and their interaction mechanisms with climate change.

Keywords: Coarse mode aerosol; Spatial-temporal pattern; Global distribution; Trend analysis

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1. Introduction

Aerosols, composed of suspended solid and liquid particles, vary significantly in space and time due to their short atmospheric lifespan and diverse sources^[1]. Coarse-mode aerosols, originating from natural sources like desert dust and sea salt, and fine-mode aerosols, primarily from human activities, contribute to this complexity

^[2]. Understanding the distribution of coarse-mode aerosols (CAOD) is critical for assessing their climate and environmental impacts. In recent years, advancements in satellite remote sensing have facilitated progress in monitoring and studying CAOD ^[3]. However, the limited data duration and high uncertainties of satellite products have constrained CAOD's applicability in climate research ^[4]. To address these challenges, Zhou Zang et al. proposed a novel spatiotemporal collaborative deep learning model (SCAM) for the retrieval of global land CAOD from 2001 to 2021 ^[5]. Unlike traditional deep learning models, SCAM accounts for the interaction of spatiotemporal features and simultaneously captures both linear and nonlinear relationships, significantly improving the accuracy and coverage of daily global CAOD.

This study aims to utilize CAOD data retrieved by the SCAM model to conduct an in-depth analysis of the long-term spatiotemporal distribution patterns of coarse-mode aerosols from 2012 to 2021. Through this analysis, this study seeks to enhance the understanding of the role of coarse-mode aerosols in global climate change and their potential impacts on the environment and human health.

2. Data

To systematically describe the spatiotemporal distribution patterns of global CAOD, this study utilized the global land coarse-mode Aerosol Optical Depth (CAOD) dataset, based on the SCAM (Semi-Continuous Aerosol Module) algorithm. The dataset, covering daily CAOD data from 2012 to 2021, is accessible at <https://zenodo.org/records/7829679>. This CAOD dataset provides a crucial foundation for analyzing the spatiotemporal characteristics of global coarse-mode aerosols. Due to its high sensitivity to coarse-mode aerosols, the dataset effectively captures the distribution characteristics of coarse aerosols and is significant for exploring the relationship between climate change and aerosols. The SCAM-derived global land CAOD dataset features a spatial resolution of 0.5° x 0.5° and a daily temporal resolution.

3. Results

3.1. CAOD Global temporal pattern

Figure 1a presents the annual average CAOD from 2012 to 2021. The CAOD reached its lowest points in 2014 and 2019, with peaks in 2012, 2016, and 2021. The minimum value (0.0806) occurred in 2019, while the maximum value (0.1003) was observed in 2012. Overall, global CAOD showed a fluctuating downward trend from 2012 to 2021. **Figure 1b** and **Figure 1c** display the annual average CAOD for the Northern and Southern Hemispheres, respectively, during the same period. The annual average AOD 550 ranged from 0.0934 to 0.1186 in the Northern Hemisphere and from 0.0421 to 0.0512 in the Southern Hemisphere, with the Northern Hemisphere significantly higher than the Southern Hemisphere. Additionally, linear regression analysis (dashed lines) was conducted in **Figure 1**. The linear regression equation is defined as:

$$CAOD(x)=Ax+B$$

In the equation, x represents the predictor (year), which corresponds to the sequence of years. A is the slope of the linear regression equation, and B is the intercept. Both the predictor (year) and the predicted value (CAOD) follow a t-distribution with 16 degrees of freedom, as well as an F-distribution with 1 degree of freedom in the numerator and 16 degrees of freedom in the denominator. The R-values for the linear regression

equations for the global, Northern Hemisphere, and Southern Hemisphere were -0.57633, -0.60949, and -0.11125, respectively. The linear regression analysis revealed negative slopes for all three cases, indicating a clear downward trend in global CAOD (global: -0.00121/year, Northern Hemisphere: -0.00164/year, Southern Hemisphere: -0.00009/year), with a significance level greater than 95%.

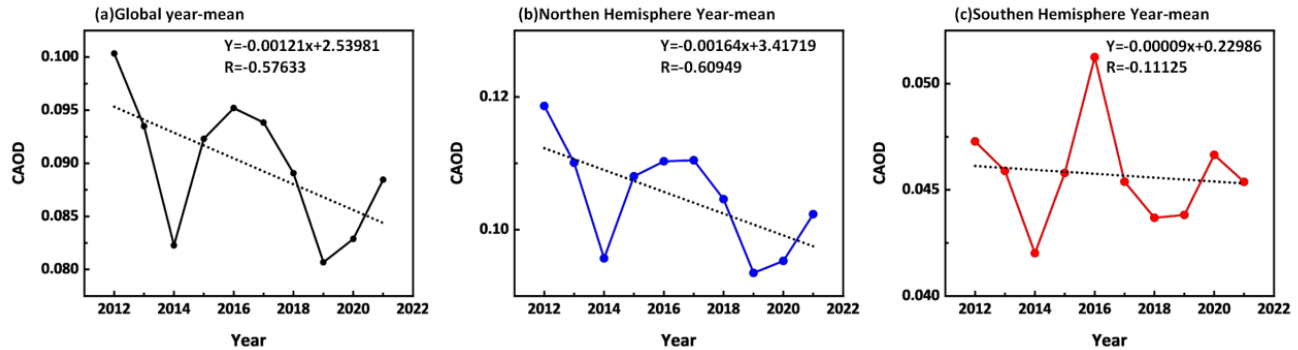


Figure 1. Annual average CAOD from 2012 to 2021 for (a) Global, (b) Northern Hemisphere, and (c) Southern Hemisphere

3.2. CAOD global latitude and longitude distribution

Figure 2 illustrates the global distribution of coarse-mode Aerosol Optical Depth (CAOD) across different latitudes. CAOD values are lower in the high latitudes of the Southern Hemisphere (-70° to -30°) due to minimal human activity and a pristine environment ^[6]. In the mid-latitudes (-20° to 20°), CAOD increases, influenced by human activities and natural sources like desert dust ^[7]. In the Northern Hemisphere (20° to 40°), CAOD values show complex variations, with lower median values (0.138 to 0.146) between 20° and 30° , and fluctuating values (0.075 to 0.056) between 30° and 40° , driven by diverse climates and human activity ^[8]. In the Western Hemisphere (-180° to -90°), CAOD remains low due to fewer human activities and natural sources ^[9]. Conversely, the Eastern Hemisphere (0° to 180°) shows higher CAOD, especially near the Sahara and Gobi Deserts, where strong winds elevate dust levels, particularly in spring and summer ^[10]. Overall, CAOD values exhibit a clear latitudinal dependency, ranging from low values in the Southern Hemisphere to complex variations in the mid-latitudes of the Northern Hemisphere. These findings provide crucial data for understanding the role of coarse-mode aerosols in global climate change. The longitudinal distribution characteristics also reflect the combined influence of natural and anthropogenic factors in different regions, offering key insights into the impact of coarse-mode aerosols on global climate dynamics.

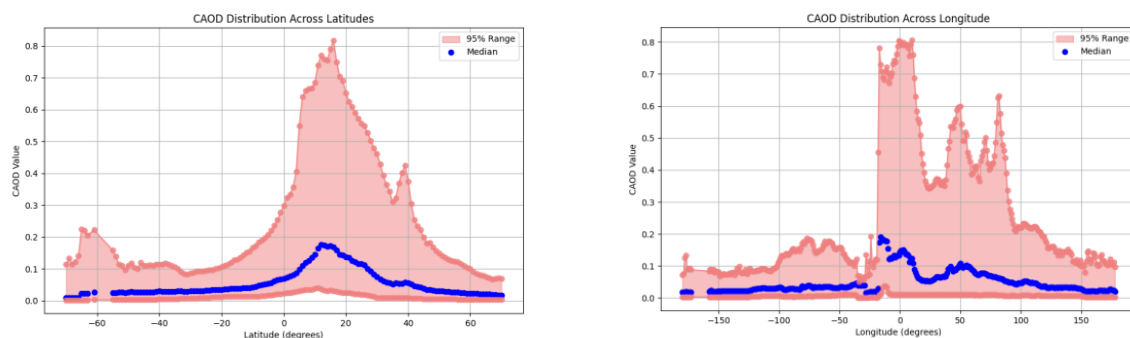


Figure 2. Mean CAOD values by latitude (A) and longitude (B)

3.3. CAOD global spatial pattern

Figure 3 shows the analysis of the spatial distribution of global coarse-mode Aerosol Optical Depth (CAOD) from 2012 to 2021. High CAOD values are observed in North Africa, the Middle East, and parts of Asia, driven by desert dust from regions like the Sahara and the Arabian Desert, and amplified by industrialization and urbanization ^[11]. In contrast, South America, Australia, and Antarctica exhibit low CAOD due to minimal human activity and cleaner atmospheric conditions ^[12]. Mid-latitude regions in the Northern Hemisphere show varied CAOD levels, influenced by diverse climates, topography, and human activities. Industrialized areas in Europe and North America see elevated CAOD, while Asia's values are affected by monsoonal variations ^[13]. This CAOD map highlights the global distribution of coarse aerosols, offering insights into their impact on climate, air quality, and health, and emphasizes the need for targeted environmental policies.

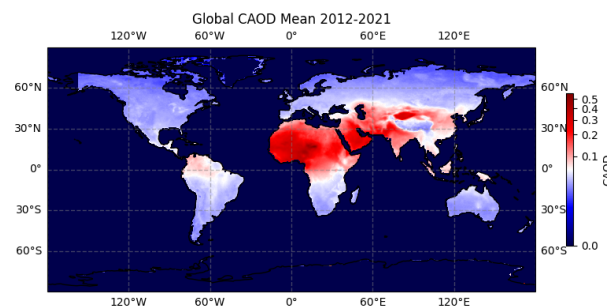


Figure 3. Global distribution of CAOD

4. Conclusion

This study analyzes global coarse-mode Aerosol Optical Depth (CAOD) data from 2012 to 2021, revealing its distribution characteristics and trends across the globe. The results indicate that global CAOD values showed a fluctuating downward trend during the period from 2012 to 2021, with a more significant decline in the Northern Hemisphere. This phenomenon may be linked to global climate change, desertification levels, and regional differences in human activities. In terms of spatial distribution, CAOD values are abnormally high in North Africa, the Middle East, and parts of Asia, which can be attributed to the widespread desert areas, strong wind effects, and rapid industrialization in these regions. Desert dust activities and anthropogenic aerosol emissions in these areas jointly contribute to the increase in CAOD values. In contrast, regions such as South America, Australia, and Antarctica show relatively low CAOD values, likely due to cleaner atmospheric conditions and lower levels of human activity. Additionally, the CAOD values in mid-latitude regions of the Northern Hemisphere exhibit complex variations influenced by diverse climate conditions, topographical features, and the distribution of human activities. In some parts of Europe and North America, higher CAOD values are observed due to elevated industrialization and traffic emissions. In Asia, the CAOD values are influenced by the monsoon climate, showing distinct seasonal variations.

The findings of this study not only provide visual evidence for understanding the global distribution of coarse-mode aerosols but also offer valuable insights into evaluating the impact of aerosols on regional climate, air quality, and human health. These results emphasize the importance of considering geographical

differences in aerosol distribution in global climate change research, and they provide scientific support for the formulation of targeted environmental policies and interventions. Future research could further explore the specific contributions of aerosol sources in different regions and the interaction mechanisms between aerosols and climate change.

Disclosure statement

The author declares no conflict of interest.

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The Research on Strengthening the Training of Inter-disciplinary Foreign Language Talents in Shenyang City and Helping to Build a Community with a Shared Future for Humanity

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Abstract: In the era of globalization, the concept of a community with a shared future for humanity, proposed by China, aligns with the overarching trajectory of human societal advancement. To actualize this vision, enhancing the cultivation of versatile foreign language professionals in Shenyang is of paramount significance. This paper delves into the theoretical aspects, examines the contemporary backdrop, scrutinizes the current state and challenges faced in the development of such talents in the city, and suggests practical remedies.

Keywords: Globalization; Compound foreign language talents; Community with a shared future for humanity; Shenyang citizens

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1. Introduction

When engaging with the Chinese and international media during the 20th session of the Political Bureau of the CPC Central Committee, General Secretary Xi said “We will continue to hold the common value of peace, development, fairness, justice, democracy and freedom for mankind, maintain world peace, promote world development, enhance the building of community with a shared future for mankind.” Once more, China has declared to the global community its commitment to fostering a shared future for humanity and advancing the creation of a new type of international relations characterized by cooperation and mutual benefit. The vision of a shared future for mankind represents a practical strategy offered by China in alignment with the overarching trends of human societal progress. Shenyang, a pivotal central city in Northeast China, renowned for its advanced equipment manufacturing and rich historical and cultural heritage, is poised to take on significant

responsibilities. As per the data from the seventh National Population Census conducted in 2020, Shenyang's population stands at 9,070,093, constituting 21.29% of Liaoning Province's total population ^[1]. There are many famous Universities—Northeastern University, Liaoning University, Medical University of China, Shenyang Normal University, Shenyang University, etc., which have trained many top talents in various fields in China. Advancing the development of a shared future for humanity necessitates a robust support system of skilled individuals. This is particularly true for those who possess an interdisciplinary approach to foreign languages, coupled with a global perspective, extensive professional expertise, and a profound capacity for cross-cultural comprehension ^[2].

Overall, the city has achieved certain progress and accumulated valuable experience in cultivating versatile foreign language talents. However, there are still some issues, challenges, and shortcomings in the training process.

2. The existing problems

2.1. The concept of cultivating compound talents is insufficient, and it does not fit well with the development of a community with a shared future for humanity

At present, the development of foreign language expertise and the nurturing of individuals to foster a shared future for humanity remain inadequate.

2.2. The city does not have strong teachers and there is insufficient interdisciplinary teaching organization

On the one hand, the number of teachers with both professional knowledge and high foreign language levels is still scarce. On the other hand, the insufficient allocation of interdisciplinary teaching resources and the insufficient organizational cooperation also leads to the difficulty of opening interdisciplinary professional courses for foreign language majors.

2.3. The teaching mode is relatively traditional, and the practical teaching is insufficient

The comprehensive quality of international vision and innovative spirit of college students in the city needs to be improved, and scientific adjustments and supplements should be made in the curriculum.

Therefore, it is particularly important to strengthen the training of inter-disciplinary foreign language talents in Shenyang ^[3]. To do this, three aspects need to be followed.

3. The improved methods

3.1. Firmly build a sense of community with a shared future for humanity

The community with a shared future for humanity embodies the Chinese people's basic viewpoint of grasping the world's development. General Secretary Xi said: "The community with a shared future for mankind, as the name implies, fits the fate of each nation and each country together, The whole world should share weal or woe together, build the planet into a harmonious family, make the people all over the world yearning for a better life into reality." Shenyang citizens should firmly build a sense of community with a shared future for humanity, bind the benefit of Chinese people up with the benefit of people all over the world, abide by the concept of "sharing the same fate", and deal with the problems and challenges facing all mankind together.

The 19th National Congress of the Communist Party of China stated that the youth hold the key to the future. If the youth are strong, the nation will be strong ^[4]. As long as the young generation has ideals, skills, and a sense of responsibility, the nation will be promising and prosperous. Serving as a pioneering force in achieving the great rejuvenation of the Chinese nation, the youth of Shenyang city should steadfastly cultivate a sense of community with a shared future for humanity, embedding this concept deeply into their studies and contributions to socialist development ^[5].

3.2. Constantly broaden the development space of foreign language teachers within universities in Shenyang city

Foreign language education plays an extremely important role in promoting the people of the world to fully understand China, promoting the “going out” of the excellent traditional culture of the Chinese nation, and accelerating the internationalization of Chinese culture ^[6]. “Teachers, are supposed to teach knowledge and solve confusion.” Foreign language teachers are not only the inheritors and disseminators of language and language cultures, but also the organizers and guides of teaching activities.

The proficiency of foreign language educators is pivotal to the caliber of foreign language instruction. Consequently, to develop versatile foreign language talents, it is imperative to initially enhance the professional competence of foreign language teachers within Shenyang city. Particularly for university foreign language instructors in Shenyang, as they are tasked with both exploring advanced teaching methodologies and training primary and secondary school foreign language educators ^[7]. University foreign language instructors in Shenyang city need to align with the demands of the current era, possess a broad international vision, outstanding practical innovation ability, and self-development ability, constantly update their ability structure, expand their knowledge dimension, and improve their professional teaching skills and scientific research literacy. They should possess multi-disciplinary education teaching ability, master the latest technical achievements, promote teaching reformation, and set a moral example for students. They should guide students correctly and cultivate foreign language talents that meet the needs of socialist modernization ^[8].

3.3. To enhance the development of versatile foreign language talents within universities in Shenyang city

As the global economy surges forward, the interconnections among nations are becoming increasingly tight, the traditional mere linguistic talent training mode has been unable to satisfy the demands of economic globalization. Therefore, foreign language education in all universities in the city should meet the market requirements for diversified foreign language talents and emphasize the cultivation of versatile foreign language experts. So that foreign language talents can be provided with high-quality language accomplishment and relevant professionalism. Foreign language educators should carry out foreign language teaching and research centering around students and adjusting the foreign language teaching objectives. Educators should apply advanced educational technology, master the latest developments in English teaching, and form a targeted foreign language teaching system for the development of the new era. Simultaneously, it is crucial to focus on the education and development of foreign language talents, incorporating the concepts of socialism with Chinese characteristics and core socialist values, strengthen the cross-cultural communication and communication ability of foreign language talents, promote the communication and integration of ethnic groups in the world, realize the common prosperity and development of different cultures, thereby offering robust and

ample talent backing for the development of a shared future for humanity ^[9].

4. Conclusion

The concept of a community with a shared future for humanity is a strategic vision put forward by China to harmonize both international and domestic contexts. It is grounded in Marxist perspectives and methodologies, and it integrates the wisdom of China's fine traditional culture. This vision serves as the fundamental objective of China's foreign policy, which aims to protect national sovereignty and territorial integrity while fostering global peace and development. Mastery of foreign languages acts as a gateway to the global stage. Talented individuals who are highly skilled, versatile, and well-rounded in foreign languages play a crucial role. They are instrumental not only in advancing the vision of a shared future for mankind but also in driving China's economic expansion, tapping into international markets, and assisting businesses in their global endeavors ^[10]. Therefore, Shenyang citizens should firmly establish a sense of community of human destiny, grasp the connotation of the era, and make it rooted. Foreign language teachers should follow the development of the era, constantly broaden their own development space, and improve their multidisciplinary teaching abilities, as well as comprehensive qualities of teaching and research. In the context of economic globalization, the foreign language education institutions in the city should improve the system of cultivating talents who possess profound humanistic feelings, noble moral character, broad global vision, excellent language skills, rich interdisciplinary professional knowledge, and strong cross-cultural communication ability. May all ethnic groups across the globe collaborate for mutual benefit and joint progress, working together to forge a superior global community.

Disclosure statement

The author declares no conflict of interest.

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International Technology Transfer Perspective: A Study on China's Compulsory Licensing System for Pharmaceutical Patents

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Abstract: Ensuring the supply of medicines is extremely important during major public health crises. Implementing compulsory licensing of pharmaceutical patents is a means to guarantee an adequate and effective supply of medicines. Although China's current compulsory licensing system for pharmaceutical patents has clear legal provisions, there are many issues. To ensure the effective implementation of the system, it is necessary to relax the qualifications of the applicants, add new objects of compulsory licensing, clarify the reasons for application, and explore more efficient application procedures.

Keywords: Compulsory licensing; Public health crisis; Pharmaceutical patents; TRIPS agreement

Online publication: January 23, 2025

1. Introduction

The frequent occurrence of global public health safety events poses a significant threat to human health and has caused major economic losses to the world. In these events, the high cost of medicines due to pharmaceutical patents is particularly prominent, especially in developing countries and regions. The general public cannot afford expensive medicine costs, which makes it difficult for moderately or severely ill patients to obtain reasonably priced and effective medicines. This exacerbates the difficulty of resolving public health crises. In this situation, the introduction of the compulsory licensing system for pharmaceutical patents can find a balance between individual interests and public interests. The system allows the government to authorize third parties to produce or sell patented medicines without the consent of the patent holder under specific circumstances to meet public health needs. This approach can promote the completion of the medicine transaction process in a timely manner to meet the urgent demand for special patented medicines without infringing on patent rights through the intervention of public institutions.

2. China's compulsory licensing system for pharmaceutical patents

2.1. Concept

The compulsory licensing system for patents refers to a legal mechanism where administrative departments such as the National Intellectual Property Administration allow third parties to produce, sell, or import patented products or use patented methods without the authorization of the patent holder under specific conditions. The patent holder then receives a certain remuneration from the licensee. This system aims to balance the interests of patent holders and social public interests, especially in emergencies or public health crises, to ensure the accessibility of key technologies or medicines^[1].

2.2. Conditions for use

This usually occurs when the patent owner refuses to authorize, or when an agreement cannot be reached within a certain period. In such cases, third parties can apply to the patent management authorities for compulsory licensing. In some emergencies or public health crises, the government may also grant compulsory licensing for the sake of public interest. In any case, the party obtaining compulsory licensing must pay a certain usage fee to the patent owner. If the two parties cannot reach an agreement on the fee, it will be determined by relevant national departments. In special situations, such as when public health is seriously threatened, the state may issue a compulsory license for pharmaceutical patents, allowing third parties to produce generic drugs with the same effect as patented medicines to safeguard public health rights and interests^[2].

2.3. Value foundation

2.3.1. Preventing the abuse of pharmaceutical patent rights

The TRIPS agreement regards intellectual property as a private right, allowing pharmaceutical patent holders to reasonably regulate market supply and pricing to recoup their investments and achieve economic benefits. However, some large enterprises use pharmaceutical patents to strengthen their market monopoly positions, restrict competition, and thus destroy the free order of market competition. To limit the unrestricted use of pharmaceutical patent rights and break the malicious monopoly situation, the compulsory licensing system for pharmaceutical patents plays a key role.

2.3.2. Alleviating public health crises and safeguarding basic human rights

The right to health is considered a basic human right and holds an extremely important position. In recent years, various infectious diseases have caused serious epidemics worldwide, posing significant public health challenges to countries. As emphasized in the Doha Declaration, the protection of intellectual property should not hinder a country from taking necessary measures to safeguard public health but should aim to promote member states in ensuring public health, especially ensuring that people can obtain essential medicines^[3].

3. Deficiencies in China's compulsory licensing system for pharmaceutical patents

3.1. Strict application subjects

China's patent law clearly limits the qualifications of applicants for compulsory licensing of pharmaceutical patents, usually only allowing government agencies to apply. For other types of compulsory licensing, applicants are usually "entities or individuals with the conditions to implement" or "persons with direct interests." Although the patent law allows individuals to apply for compulsory licensing to prevent the abuse of

patent rights, when the requirement of “having the conditions to implement” is added, the number of individuals who can meet this condition is greatly reduced.

3.2. Narrow scope of application

According to the provisions of the Patent Law Implementation Regulations, the objects of compulsory licensing are limited to “patented products or products directly obtained by the patented method.” This means that only patented medicines that have been granted patent rights can become the objects of compulsory licensing, while those pharmaceutical technology solutions that are in the patent application stage and have not yet obtained patent rights are not included. At the same time, China’s patent law does not have clear legal provisions on whether compulsory licensing applies to pharmaceutical patents that have not undergone clinical trials.

3.3. Ambiguous reasons for licensing

Article 54 of the Patent Law mentions that compulsory licensing can be granted in cases of “emergency”, “extraordinary circumstances”, or “for public interest”, but the definitions of these terms are not clear and lack specific standards. This results in administrative organs having a large degree of discretion in actual operations, which may affect the effective implementation of the system^[4]. In addition, the application conditions for compulsory licensing are stipulated in an enumerative manner, without including a flexible clause for “other circumstances” to cope with various unforeseen emergencies or special situations. This may lead to a lack of adaptability and flexibility of the law when facing unexpected emergencies or special situations^[5].

4. Paths to improve China’s compulsory licensing system for pharmaceutical patents

4.1. Appropriately relaxing the qualification restrictions on application subjects

For government entities, it is suggested to clarify in the law that the National Health Commission can jointly assess and propose suggestions for compulsory licensing with the National Medical Products Administration and other relevant departments to maintain public health. The scope and application procedures of “relevant departments of the State Council” should be determined, and a public supervision mechanism should be established to ensure that the government actively fulfills its duties. For social entities, it is recommended to relax the qualification of “entities or individuals with the conditions to implement” to “entities or individuals with the possibility to implement.” There is no need to require them to have actually met the conditions for implementation, as long as they have the potential to implement the patented technology subject to compulsory licensing. Finally, it is suggested to add “entities or individuals with the possibility to implement” as applicants in the patent law. Through these modifications, the flexibility and effectiveness of the compulsory licensing system for pharmaceutical patents can be improved, better serving public health needs.

4.2. Adding new objects of compulsory licensing

It is suggested to expand the definition of “medicines” in the patent law to include pharmaceutical patent applications and patented medicines that have not undergone clinical trials. Including ungranted pharmaceutical patent applications in the objects of compulsory licensing is essentially a preliminary recognition of their patent rights. This allows them to be treated as non-patented medicines when rejected while following the relevant rights and obligations stipulated in the patent law when authorized^[6].

4.3. Clarifying the reasons for the application of compulsory licensing for pharmaceutical patents

Firstly, the wording of Article 54 of the Patent Law should be adjusted to “in cases where the country faces emergencies, extraordinary circumstances, and other situations affecting public interest” to clearly express the hierarchy and connection between these concepts. Secondly, more specific definitions or standards should be provided for key terms such as “public interest”, “emergency”, and “extraordinary circumstances.” The circumstances in which “public interest” is damaged can be specifically defined, such as when medicine prices are far beyond the public’s ability to bear or when market demand is not met. Furthermore, it should be clear which diseases constitute “emergencies” or “extraordinary circumstances.” Combining the actual situation in China, infectious diseases with high incidence, strong contagiousness, and significant health hazards, as well as chronic non-communicable diseases, should be included in the scope of application for compulsory licensing of pharmaceutical patents, and specific explanations should be provided in relevant regulations. Finally, a catch-all clause such as “other circumstances that meet the reasonable needs of the public” should be added to the patent law as a supplementary reason for compulsory licensing. This will more flexibly cope with various emergencies and better safeguard public health.

5. Conclusion

In the post-pandemic era, people have a deeper understanding of the importance of public health rights to personal safety. Especially in the face of major public health emergencies, the institutional support provided by the law is extremely important for everyone. International legal practices have fully proven the importance of the compulsory licensing system for pharmaceutical patents in ensuring the availability of medicines and protecting public health. As a system arrangement that balances patent rights and public health rights, the purpose of compulsory licensing for pharmaceutical patents is not only to improve the availability of patented medicines but also a reflection of the pursuit of legal values.

Disclosure statement

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Application of Modern Information Technology in Agrometeorological Service

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Abstract: Meteorological service is the key to China's agricultural field to respond to meteorological changes and improve agricultural production quality. The application of modern information technology in agricultural meteorological services has changed the traditional method of data collection and processing of agricultural meteorological services. Meteorological services have become more accurate and intelligent as the speed and accuracy of meteorological forecasting have also been greatly improved, which can better meet the needs of modern agricultural development. Given this, this paper briefly explains the current situation and development trend of agricultural meteorological services, analyzes the application significance of modern information technology in agricultural meteorological services, and discusses the information technology related to meteorological services. On this basis, the paper puts forward specific application strategies of modern information technology in agricultural meteorological services, hoping to improve the quality of agricultural meteorological services.

Keywords: Information technology; Agriculture; Weather services

Online publication: January 23, 2025

1. Introduction

With the rapid development of modern agriculture, meteorological information plays an increasingly prominent role in agricultural production and has become a key factor to guide agricultural production and ensure food security. The traditional agrometeorological service is limited by the technical level and the information dissemination mode, and it is difficult to meet modern agriculture's demand for meteorological information with high timeliness, precision, and high coverage. The rapid development of modern information technology has provided strong technical support for the transformation and upgrading of agricultural meteorological services. This paper aims to discuss the application of modern information technology in agricultural meteorological services and analyze how to improve the ability of meteorological information collection, processing, transmission,

and application, to provide a strong guarantee for the sustainable development of agriculture.

2. The status quo and development trend of agrometeorological services

2.1. Application status of modern information technology in agrometeorological services

Modern information technology has a wide range of application space in agricultural meteorological services and has achieved certain application results. Specifically, modern information technology has subverted the traditional meteorological data collection and transmission mode. With the help of UAV, remote sensing technology, and other technical means, agricultural meteorological data can be collected in real time and accurately, and quickly transmitted and shared through Internet channels ^[1]. In addition, with the help of artificial intelligence and big data, massive agrometeorological data can be efficiently stored, processed, and analyzed, to mine more valuable information and provide a more accurate decision-making basis for agricultural practitioners.

2.2. The development trend of agrometeorological services

Meteorological services will become more personalized and precise by combining the power of modern information technology with practical agricultural production. Meteorological services can customize differentiated meteorological services for different regions and crops to accurately respond to the diversified requirements of agricultural production ^[2]. Intelligence and automation will become the new normal of agricultural meteorological services. With the help of cutting-edge technologies such as artificial intelligence and the Internet of Things, the collection and analysis of agrometeorological data will be automated to provide intelligent early warning and decision-making aid for agricultural production. Agrometeorological services are developing in a more open and shared direction. The establishment of a sharing platform and open mechanism can promote the interconnection of agrometeorological data, promote the co-evolution of services, and enhance overall efficiency. Thus, agrometeorological services will move towards integration and diversification. Based on traditional weather forecasting and meteorological data analysis, multiple agricultural information such as soil moisture and crop growth conditions will be integrated to provide farmers with more comprehensive and integrated services ^[3].

3. The significance of modern information technology in the application of agricultural meteorological services

3.1. Conducive to the sharing of agrometeorological resources

The information provided by the traditional meteorological service has a lag, which will lead to misleading agricultural producers and indirectly affect the planting and growth of crops ^[4]. At present, China's agricultural field is changing in the direction of cross-regional development, and agricultural meteorological services urgently need to make adjustments and scientific layout according to the agricultural layout and climate characteristics of different regions, to ensure help and guidance for agricultural production. With the help of the Internet and information technology, the circulation and sharing of meteorological data and products can be realized throughout the country, and the development and progress of a trans-regional agricultural economy can be promoted ^[5].

3.2. It is conducive to the development of diversified agrometeorological services

With the rapid development of science and technology, relevant researchers need to devote themselves to in-depth research on meteorological services and rely on efficient data analysis and accurate monitoring equipment

to achieve the goal of efficient collection and processing of meteorological information ^[6]. Remote sensing technology can provide agricultural resources and environmental information, such as moisture, soil, etc., as well as meteorological information required by various agricultural fields, such as cloud cover and temperature, and so on, to provide technical support for agricultural production planning and meteorological disaster early warning and evaluation. At the same time, the intelligent information processing system can process meteorological data more conveniently, and then assist farmers in formulating scientific and effective production plans in time, and effectively enhance the ability to resist natural disasters ^[7].

3.3. It is conducive to enhancing the accuracy of meteorological prediction

The growth and development of crops will be affected by the change of climate and the change of seasons, and abnormal climate will lead to the reduction of crop yield and even the occurrence of diseases and pests. To ensure the timely and accurate transmission of meteorological information, farmers can accurately grasp the sowing time and provide an implementation basis for subsequent fertilization and irrigation operations ^[8]. In the busy farming season, farmers pay special attention to all kinds of meteorological information, especially extreme weather conditions such as frost, strong wind, and precipitation. Thanks to the strong support of modern information technology, the accuracy and science of meteorological information have been greatly improved, so that agricultural practitioners can carry out scientific planting, and thus improve the yield and quality of crops.

4. The key technologies of agricultural meteorological service application based on modern information technology

4.1. Data collection and processing technology

Advanced sensors and monitoring equipment, such as temperature sensors, rainfall sensors, and so on, enable real-time monitoring of key meteorological elements such as temperature and rainfall in the environment. The integration of these sensors and the Internet of Things technology can improve the accuracy of data acquisition and analysis, and reduce the error caused by human factors ^[9]. Through high-speed wireless communication technology, such as TPUNB technology and LPWA technology, it can provide suitable field operation environment data transmission technology, to provide the whole process of crop growth detection, and realize integrated water and fertilizer management. The cloud computing platform can quickly store and analyze the massive raw data generated by various farmland equipment, and extract valuable information to provide guidance for agricultural production. In addition, artificial intelligence, especially the application of machine learning algorithms, can automatically analyze, learn, and predict future meteorological trends based on historical meteorological data, improving the accuracy of meteorological forecasts ^[10].

4.2. The application of information technology in meteorological forecasting technology

In terms of meteorological monitoring, remote sensing technology is also being used to monitor meteorological changes. Modern meteorological forecasting uses remote sensing technologies, such as sounding and satellites, to monitor farmland environment and obtain meteorological data such as atmospheric temperature, cloud cover, and precipitation, providing information support for meteorological forecasting, climate change, and disaster early warning ^[11]. This data information will be transmitted to the meteorological processing center, through the computer system for processing and analysis. Weather forecasting models are used by meteorological departments to simulate and predict weather changes, providing additional assurance for agricultural decisions. Finally,

by using visualization technology, the complex forecast results are transformed into concise weather forecast information and transmitted to farmers.

4.3. Agricultural expert system

The main purpose of agricultural expert systems is to use the knowledge of human experts to solve problems in the field of agriculture. It carries a large amount of expert-level agricultural knowledge, through the collection of crop growth information and farmland meteorological information analysis, combined with a large amount of experience and knowledge in the system and imitates human problem-solving strategies, to generate targeted agricultural decision-making guidance suggestions. It provides detailed guidance for farmland management and crop planting timing, irrigation amount, and fertilizer amount to assist farmers in planning scientific and reasonable agricultural production programs ^[12].

4.4. Internet of Things technology

With the help of sensors and monitoring devices, real-time farmland meteorological data can be collected, and these data can be uploaded to the cloud platform through the Internet of Things technology, so that farmers can obtain the latest farmland meteorological information immediately through smart mobile devices, to achieve remote monitoring of farmland ^[13]. In addition, by connecting farmland equipment with the Internet of Things, such as the greenhouse control system and the Internet of Things, the system can automatically adjust temperature parameters according to the real-time meteorological data and the actual needs of crops, effectively saving farmers' labor costs and time costs.

5. The application measures of modern information technology in agricultural meteorological services

5.1. Establishing a complete meteorological forecasting system

The level of meteorological service directly affects the effect of agricultural disaster prevention and reduction. To effectively resist natural disasters, it is necessary to strengthen meteorological monitoring and keep track of climate change, detect climate anomalies in time, and take effective preventive measures to ensure the steady progress of agricultural production ^[14]. In this regard, it is necessary to strengthen the management of meteorological work, build a perfect meteorological monitoring network, follow the established norms to operate, and fully grasp the actual situation of climate. At the same time, weather forecasts should be released through diversified information channels, so that farmers can take appropriate disaster prevention measures in advance.

5.2. Information sharing promotes the development of new agriculture

With the development of modern agriculture, the traditional meteorological service system has limited agricultural production, and its support for the agricultural field is inadequate. At the same time, in terms of concept and technology, the traditional weather forecast business also has certain limitations. With the development of the information age, the weather forecasting business is also ushering in new development opportunities. With the help of modern information technology, farmers can obtain more diversified and detailed weather information, which provides more complete weather data for China's agricultural development.

5.3. Establishing a meteorological service platform

Through various media channels such as websites, new media, and television, service sites can be established in each region to build a comprehensive professional service platform. In addition, for different types of natural disasters, it is necessary to establish a systematic management system and formulate corresponding coping strategies according to specific problems to improve the efficiency of emergency response.

Relevant departments should build agricultural meteorological service platforms based on local conditions and release meteorological information in a timely and accurate manner. The platform should also provide agricultural producers with scientific planting suggestions and disaster prevention and reduction programs to further expand the field of agrometeorological services. In the process of construction of the platform, modular service items should be provided on the website according to different needs, so as to provide agricultural producers with more high-quality and convenient meteorological information services.

5.4. Innovative meteorological service means and models

Meteorological monitoring and forecasting play an important role in the traditional agrometeorological system. With the progress of modern science and technology, agroclimatic service needs to highlight its unique media attributes of the times and optimize and improve the traditional media service to provide high-quality public climate service to agricultural production and economic growth^[19]. In addition, the continuous optimization of 5G network technology and the continuous innovation and progress of all media make people prefer to obtain all kinds of information through mobile devices. Therefore, agrometeorological services should also keep up with the pace of the times, combine the actual needs of different agricultural production, and formulate personalized information push models. To provide more accurate and scientific guidance and reference for agricultural production.

5.5. Improve disaster reporting and real-time information feedback mechanisms

To build a comprehensive information feedback system, disaster reports can be compiled to create favorable conditions for the benign interaction between the people and the grass-roots meteorological bureau, to effectively avoid the simplification of the weather forecast service system. In addition, the system can integrate weather information provided by the public with expert analysis, to make more accurate forecasts and disseminate them in time. For example, a volunteer team of meteorological disaster reports can be organized to promote the prevention and control technology of meteorological disasters. At the same time, a special hotline can be set up to collect all kinds of weather and disaster information in time and store it in the corresponding database after pretreatment, to improve the ability of the agricultural defense system to seek advantages and avoid disadvantages.

6. Concluding remarks

In a word, meteorological service can provide a guarantee for the safety and stability of agricultural production, reduce the loss caused by meteorological disasters, improve the quality and level of meteorological service, and provide a basis for agricultural production decision-making, which is the application significance of modern information technology in agricultural meteorological service. Through big data analysis, agricultural producers can grasp the laws of climate change more accurately and make scientific planting plans. The application of the Internet of Things technology can monitor the farmland environment in real-time and regulate farmland equipment intelligently. The integration of artificial intelligence further improves the intelligent level of weather forecasting and the accuracy of disaster warnings. In the future, with the continuous progress of technology and

integrated innovation, modern information technology will play a more important role in the field of agricultural meteorological services, help agriculture develop in a greener, smarter, and more efficient direction, and contribute more to the increase of farmers' income and the prosperity of rural areas.

Disclosure statement

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Regarding the Evolution of BRM Simulator Training Concept in the Framework of MASS

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Abstract: As artificial intelligence (AI) has advanced, there has been a lot of discussion and worry about academic theoretical research on MASS. The concept and facilities of BRM simulator training for MASS will be changed. BRM simulator training serves as a link between nautical theory and practice, which is crucial for the creation of MASS and the specification of MASS. This paper examines and discusses the transformation of BRM “resources” and the fresh requirement for instructor competency. The concept of BRM training for MASS is to change the focus from knowledge, skills, and attitudes to developing managerial competencies for judgment, analysis, and decision-making.

Keywords: MASS; BRM simulator; Conceptual change; Decision-making capability

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1. Introduction

Education, science and technology, and talent are the key and strategic pillars for the comprehensive construction of a modern socialist nation, according to the Chinese government, which has outlined its clear strategic thinking for accelerating the development of a powerful maritime and transportation power. Universities must actively support business and commercial demands as well as national initiatives. Universities must actively support the implementation of key national strategies like innovation-driven development, the Belt and Road Initiative, Made in China 2025, and Internet Plus, as well as industrial transformation and upgrading, to meet the challenges of a new round of scientific and technological revolution and industrial transformation. Training the nation’s senior maritime talent to compete internationally is the responsibility of higher maritime education. Future unmanned ship usage and the ongoing advancement of ship intelligence provide new difficulties for maritime professional training. Actively advocating for the reform of maritime education and raising the standard of instruction for marine professionals is essential.

Research on the use and significance of BRM simulators in maritime education has been published, and

they are crucial in developing shipping talent. According to some academics, the BRM simulator ought to emphasize formal diversity and build a platform that allows the crew on the bridge to participate ^[1]. A ship crash instance has been utilized by some researchers to highlight the significance of BRM in the judicious use and distribution of resources, including information, material, and human resources ^[2]. A ship crash instance has been utilized by some researchers to highlight the significance of BRM in the judicious use and distribution of resources, including information, material, and human resources ^[3]. A research approach for maritime education has been put up by certain scholars and is based on the trinity of information, skills, and attitudes found in the BRM simulator ^[4]. Drawing from previous research, this paper combines the “Guidelines for the Construction of an Intelligent Ship Assembly Standard System 2020 Edition” and the “Intelligent Ship Specifications 2024” to propose that the primary focus of the BRM simulator training concept in the context of MASS should be the development of management capacity for analysis, judgment, and decision-making, as well as the capacity requirements for training facilities, equipment, and teaching staff.

2. BRM simulator training “resources” requirements, understanding, and transformation

To prevent marine mishaps brought on by careless or inappropriate use of resources during actual navigation, BRM simulator training aims to acquaint trainees with the bridge’s operational environment and the effective use of bridge-related resources. Consequently, it is crucial to use BRM simulator training. To do this, the Chinese Ministry of Transport’s Maritime Safety Administration has established hardware and instructor specifications for training facilities, and academic institutions have carried out critical studies on the concept and materials of BRM simulator training.

2.1. Hardware requirements for BRM simulator training “Resources”

The location, amenities, and equipment of the training facility are essential for BRM training. Only if the fundamental hardware prerequisites are met can the training needs and objectives be met. The Maritime Safety Administration of the People’s Republic of China’s Ministry of Transport has developed and issued the “Measures for the Implementation of the Regulations of the People’s Republic of China on the Training of Seafarers” (henceforth referred to as the “Measures”) in compliance with the STCW Convention to prevent inconsistencies or failure to attain the anticipated training quality. In terms of the appropriate locations, amenities, tools, and teaching personnel required for seafarer training, the “measures” outline the pertinent requirements for maritime training institutes to conduct seafarer training ^[5].

The “measures” include 48 “resources” required for traditional navigation to guarantee the safe passage of ships, including multimedia classrooms, teaching nautical charts, teaching nautical books and materials in both Chinese and English, teaching “log books”, chart tables, and chart work tools. It has also been established how much of the necessary “resources” are required. The following are prerequisites for instructors of practical training: Theoretical instructors must: 1) work for themselves; 2) be captains of the respective navigation areas; 3) have at least one instructor for each ship’s ship handling simulator and one instructor for the console; 4) have other practical training instructors hired from outside, with a student-to-teacher ratio of 1:20.

The environment, tools, and supplies needed for navigation on a classic ship’s bridge must be met by the site, facilities, and equipment criteria in the “measures.” The aim is to accomplish the BRM training objectives while

simulating and restoring the bridge's actual condition as much as possible while the ship is sailing. It is possible to separate theory from practical training when it comes to the requirements for instructors of practical training. The practical training instructor must have at least one captain of the relevant navigation area level; however, the theory instructor does not need to have any prior maritime experience. Consequently, in the conventional ship BRM training that is now in place: To achieve the training's purpose and goal, 1) the theoretical and practical training instructors can train the trainees independently, and the theoretical instructor must be the training institution's instructor; 2) the practical training instructor places more emphasis on sailing experience, which can reflect the dual combination of training ability and experience; and 3) the teacher-student ratio is taken into consideration for other practical training instructors, who can be hired from outside.

2.2. Traditional BRM simulator training's understanding of "resources"

The term "bridge resource management" describes the methods, actions, or approaches used to manage the different accessible "resources" in a ship's bridge's working environment, as well as the organization and control of these resources ^[6]. In bridge resource management, the following resources are frequently utilized: 1) Human capital. The employees in charge of ship navigation are the primary target of management or utilization. The knowledge, abilities, experience, and personal skills of the staff, as well as their potential and capacity for teamwork, are the primary emphasis of people management. 2) Tangible assets that primarily refer to the instruments or navigational aids that guarantee navigation safety in conventional ship navigation. The ship navigation staff gathers the relevant ship navigation parameters and data from the navigation instruments and equipment, compiles and filters this information, and then takes the next navigation scenario into account. 3) Resources for information that mostly refer to the staff members in charge of ship navigation summarizing and analyzing nautical manuals and other directives or information. 4) Additional resources. Additional resources include the time, space, expertise, abilities, collaboration, and support of pertinent departments needed to guarantee the ship's regular operation and navigation.

The person in charge of a ship's navigation must use all available information, parameters, data, and so on to plan, organize, control, and coordinate the rational application of management, operate the necessary equipment correctly, direct operations rationally and accurately, and coordinate the relationships between all relevant parties to achieve effective control over the organization and implementation of operations on site and, ultimately, accomplish the goal of ensuring the ship's safe navigation.

2.3. The transformation of the BRM "resources"

The development of MASS will also be a future trend, and its research and trial operation has garnered a lot of attention in recent years. Examples like Yara Birkeland could be a clear indication that shipping needs to change ^[7]. China has, in the meantime, made great strides in the study of intelligent ships and has established relevant laws to support these studies and the creation of standards for them. For instance, according to the "Intelligent Ship Code 2024" (henceforth referred to as the "Code"), an intelligent ship uses technological tools like sensors, communications, the Internet of Things, and the Internet to automatically perceive and gather information and data about the ship itself, the maritime environment, logistics, ports, and so on. It also provides computer technology, automatic control technology, and big data processing and analysis technology to achieve intelligent operation of the ship in terms of navigation, management, maintenance, cargo transportation, and so on, making the ship safer, more economical, more ecologically friendly, and more efficient ^[8].

Consequently, the code's description of an intelligent ship will result in different BRM training concepts for intelligent and conventional ships. Ships with intelligence are capable of intelligent navigation. They can gather information about the ship's navigation status using sophisticated perception and sensor information fusion technologies, analyze and process it using computers and control technology, and then offer recommendations to help with navigation decisions. Additionally, they have features like visual enhancement, collision warnings, warnings of running aground, route design and optimization, and comprehensive information display. These features can be used gradually, ranging from autonomous navigation in open waters to autonomous navigation for the duration of the journey.

The "resources" that correspond to traditional BRM have changed, as can be seen from the needs of the "norm," and this change is particularly evident in 1) The human resource transformation. The management of the expertise, experience, and understanding of conventional human crew members is no longer the main focus because intelligent ships possess intelligent navigation capabilities. 2) Material resources are transformed. The measures necessary for the ship's navigation are established once the information has been artificially integrated. Traditional navigation depends on the information gathered from various navigation aids. However, after thoroughly examining pertinent navigation data, intelligent navigation can offer recommendations regarding the travel scenario and actions to be followed. 3) Information resource transformation: Intelligent ships are capable of optimizing and designing their routes. They can create routes using weather forecasts and electronic route data, analyze navigation data while the ship is navigating, and optimize the route. This differs from the conventional BRM training, which entails summarizing and evaluating nautical literature and other data. 4) Transformation of other resources: Intelligent ships prioritize collaboration and support between shore-based and shipboard staff over collaboration between the engineering and deck departments of a traditional ship or technical assistance provided to shipboard staff by the company's engineering and marine departments.

3. MASS seaworthiness, BRM training hardware, and mindset change

In addition to MASS being a new product, MASS bridge navigation and resource management tools and objectives are also improved. To stay up with technological advancements and avoid maritime mishaps, new innovations, and technology will unavoidably result in new competency requirements. At the same time, new training concepts and methodologies are being developed to meet the new competency criteria.

3.1. Fitness requirements for MASS

To clarify the roles, qualifications, and training needs of personnel operating and using intelligent systems, as well as to mandate that pertinent personnel be knowledgeable about and proficient in operating and maintaining intelligent systems, the "Code" also lays out corresponding requirements for personnel, requiring shipowners or ship management companies to develop management measures, training plans, operating procedures, and others related to intelligent systems.

The shipowner or ship management company is identified as the responsible entity required by the "Code." For this reason, the shipowner and ship management business must set up and upgrade the operating system or management system for the firm's MASS. Simultaneously, training facilities will have to meet new standards for the education and credentials of shipboard staff, which will provide further difficulties. Therefore, training institutions should prioritize developing training concepts and hardware for MASS BRM before the widespread

usage of MASS. They should also make plans for the future to address the issues presented by MASS BRM training.

3.2. BRM training hardware and personnel transformation in the context of MASS

The “norm” outlines the primary organization in charge of managing and operating MASS, training them, and determining whether the appropriate staff is in place. It is now impossible to determine the precise needs for certain training locations, facilities, etc., because the requirements are only mentioned in broad strokes and no specific regulations have been established. However, from a different angle, the building of MASS necessitates meeting specific requirements and facility standards. For instance, China’s 2020 Guidelines for the Construction of an Intelligent Ship Assembly Standard System (henceforth referred to as the “Guidelines”) categorizes intelligent ship construction into three groups: B key technologies, such as BA interconnection and system integration, BB intelligent shipyards, BC intelligent services, and BD application of new-generation information technology; C shipyard applications, such as CA material yards, CB parts manufacturing workshops, CC small-group erection workshops, CD sectional manufacturing workshops, and other shipyard-related intelligent applications; and C basic commonality, such as AA general, AB testing, AC rating, and AD safety ^[9].

The “Guidelines” are a set of standards for building intelligent ships. The “Guidelines” outline the needs and development standards for upcoming intelligent ships. Requirements for the application of AR/VR standards are established in the guidelines’ key technologies for next-generation information technology. These include general requirements for regulating the ship construction and assembly process, interconnection, system integration, human-computer interaction, performance testing, the use of virtual reality software and data processing, and safety requirements. Training institutions may therefore need to include virtual reality software systems and specialized safety training for MASS to overcome difficulties with the hardware facilities for networking, systems, interaction, and performance testing in the BRM training hardware for MASS. Teaching staff are also being subjected to increased competency standards at the same time. Captains with related navigation areas perform practical training after BRM theoretical teachers teach trainees just nautical theory. MASS must, however, also be knowledgeable about areas like system integration, networking, intelligence, and human-computer interaction. Consequently, to train MASS BRM trainees in the future, new theoretical projects will need to be introduced, and either new theoretical teaching staff will need to be prepared, or current theoretical staff will need to earn the necessary training credentials.

3.3. BRM training concept change in the context of MASS

Human error can be decreased by BRM simulator training. When an operator in a given system completes a task, human error refers to mistakes in awareness, judgment, and behavior that result in either an operation that fails to accomplish the intended purpose or an inability to perform an operation that is appropriate for the environment and situation at the time. Human behavior that is insufficient to manage the current circumstance may result in system breakdowns. Thus, crew quality can be enhanced by BRM simulator training ^[10]. The concept of crew quality is not set in stone, though, and it could evolve in meaning and scope as social technology advances. A ship’s crew is traditionally evaluated based on their work attitude, feeling of responsibility, navigational knowledge, emergency management skills, and capacity to adjust to pressure. The crew’s jobs have gradually lessened due to MASS’s technological intelligence, and electronic technology has gradually replaced them. For example, traditional paper books and materials have gradually given way to electronic charts and books and materials.

The trinity of knowledge, skills, and attitude forms the foundation of the marine teaching philosophy of the classic BRM simulator. However, sophisticated algorithms may now determine the appropriate steps or measures that the crew or shore-based workers need to take thanks to the development of intelligent navigation systems on MASS. The crew or shore-based staff have the option to turn off the intelligent navigation system and take manual intervention if they believe the planned actions to be dangerous. As a result, the MASS BRM Simulator's nautical education approach is primarily concerned with data analysis, determining the safety of activities based on data analysis, and making decisions. As a result, the Intelligent Ship BRM Simulator training idea might be expanded to include management capacity building for analysis, judgment, and decision-making.

4. Conclusion

To guarantee that students progress smoothly from theory to practice, BRM simulator training subjects serve as a link between theoretical navigation courses and real navigation on board. Thus, it is clear how important BRM simulator training is. From the standpoint of the "resources" needed for BRM simulator training on conventional ships, the comprehension of these "resources," and the prerequisites for instructors, this article examines the changes and distinctions between intelligent and conventional ships. The creation of sentient ships is now both possible and plausible due to advancements in artificial intelligence. China's "Guidelines for the Construction of an Intelligent Ship Standard System 2020" and "Intelligent Ship Specifications 2024" presently contain the blueprints and prototypes of future intelligent ships. To offer some inspiration for future BRM simulator training for intelligent ships, this can be used to analyze and assess the concepts and "resources" for such training.

Disclosure statement

The authors declare no conflict of interest.

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The Development Framework and Practical Strategies of Traditional Culture from the Perspective of Interactive Digital Narrative

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Abstract: With the rapid development of digital technology, interactive digital narrative, as an emerging narrative method, provides a new perspective and path for the inheritance and innovation of traditional culture. Applying interactive digital storytelling to the field of cultural heritage is an important practice for the universal sharing of digital achievements in Chinese culture and the implementation of the “digital+cultural heritage” strategy. This article aims to explore the application framework and practical strategies of interactive digital narrative in the development of traditional culture. Taking traditional culture in Shenzhen as an example, a development framework of “subject medium local traditional culture” will be constructed through interactive digital narrative innovation, innovating cultural content, enhancing cultural experience, and elaborating on the strategy of storytelling expression of local traditional culture. This provides theoretical reference and practical guidance for the digital dissemination and innovative development of traditional culture.

Keywords: Interactive digital narrative; Traditional culture; Development framework; Practical strategy

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1. Introduction

Culture is the soul and foundation of a country and a nation, and traditional culture is an important carrier of national memory and historical wisdom. However, in the context of globalization, the inheritance and development of traditional culture face many challenges. On the one hand, the dissemination methods of traditional culture are relatively single, making it difficult to attract the attention of the younger generation. On the other hand, the protection and inheritance of traditional culture require a significant amount of manpower, material resources, and financial resources, which existing resources cannot meet ^[1]. Therefore, how to innovate the dissemination methods of traditional culture and enhance its attractiveness and influence, has become an urgent problem to be solved. Today, in the context of the rapid development of the Internet, the traditional cultural communication mode has undergone tremendous changes. The traditional cultural narrative focuses on the integration of scientific

and technological elements, such as “Tang Palace Banquet”, “Shangxin Forbidden City”, “National Treasures”, “Mawangdui Immortal Time”, “Dragon Boat Festival Wonderful Tour” opening dance “Prayer” and other programs have been “out of the circle.” From this, it can be seen that narrative is not only a way of telling stories but also an important tool for expanding cultural influence by incorporating technological elements. The research in this article is expected to find a new path for the inheritance and innovation of traditional culture, provide some inspiration and reference for researchers and practitioners in related fields, and promote the digital dissemination and innovative development of traditional culture.

2. Theoretical basis and development framework

2.1. Interactive digital narrative

Interactive digital narrative (IDN), abbreviated as interactive narrative, is an emerging narrative style that provides new possibilities for the development of traditional culture with its unique interactivity and immersion. Interactive narrative is a product of the development of digital media technology, which originated in the late 1860s and has gradually developed into a mature and dynamic research field. It refers to “multi-sequence narratives in which users can have beneficial effects through interactive narrative systems”, in short, user input can intervene in the narrative.

The field of interactive narrative inherits the four classic theories of Western narrative and has become an important research topic in the field of VR narrative. Currently, scholars mainly study the creative laws of interactive and intelligent narrative, narrative, interaction, and system patterns, as well as design theory and practice^[2]. Domestic scholar Li Yuan found through research that the way users participate in storytelling is through role-playing, human-computer dialogue, etc., which can enhance the user experience. Scholar Zhang Meng found through research that the core of the interactive narrative is to construct a digital narrative system. Users can activate script cognition to understand the story world in a virtual narrative experience and stimulate participants’ initiative through adventure games or interactive narratives. Foreign scholar Hamet Kouaniz found through research that interactive narrative is a form of narrative expression in multiple forms, implemented in the form of multimodal computing systems, which can enhance user experience. He believes that the core elements of the interactive narrative are the system, process, and product, and has constructed and continuously improved the SPP model.

2.2. Development framework for this article

This article aims to construct an interactive digital narrative system for local traditional culture. Taking Shenzhen’s traditional culture as an example, a development framework of “subject medium local traditional culture” is constructed. The three-dimensional interactive diagram of “subject media local traditional culture” is shown in Figure 1.

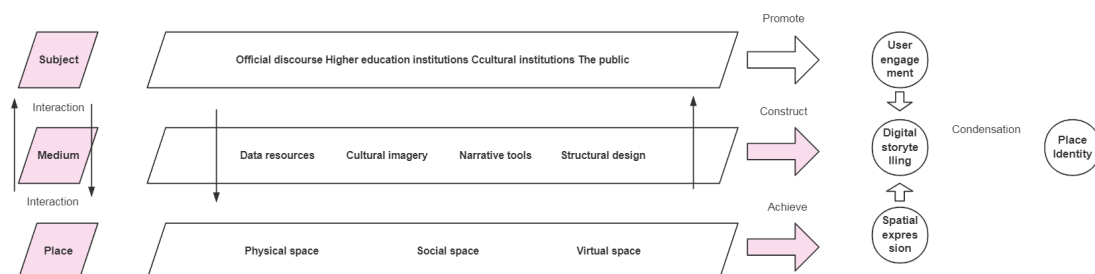


Figure 1. Three-dimensional interactive diagram of “Subject media local traditional culture”

The subject refers to the users of the system, who are the participants and experiencers of the story. Users can understand and experience the traditional culture of Shenzhen through interaction with the system. Media refers to digital technology and media forms, including metadata, semantic annotation, international image interoperability framework (IIIF), associated data, and other technical standards, as well as Chinese-style interface design and background music. These media provide users with rich sensory experiences and interactive methods. Local traditional culture refers to the core content presented by the system, including the history, art, folk customs, festivals, and other aspects of Shenzhen. Through interactive digital storytelling, users can deeply understand and feel the charm of these traditional cultures.

3. Design of an interactive digital narrative system for traditional culture

To build an effective interactive digital narrative system for traditional culture, technologies, and standards such as metadata, semantic annotation, IIIF, and related data were adopted, combined with Chinese-style interface design and background music. The construction of this system is beneficial for the public's recognition, understanding, and appreciation of traditional cultural images in Shenzhen, as well as for public cultural institutions such as libraries, archives, and museums to carry out digital curation, data visualization, moral and aesthetic education, and promote the inheritance and development of traditional culture in Shenzhen. The following is a detailed description of the system design.

3.1. Application of technology and standards

Metadata: Used to describe the basic information of digital images, such as author, creation time, location, etc., providing users with a preliminary understanding of the image and helping them search and filter in the system.

Semantic annotation: By annotating elements in an image, such as people, buildings, clothing, etc., it provides users with deeper image interpretation and background information.

IIIF: The international image interoperability framework provides a unified standard for the display and interaction of digital images. Through IIIF, image scaling, translation, rotation, and other operations can be achieved to associate and compare with other images.

Related data: Through related data technology, different digital resources (such as images, text, audio, etc.) can be linked and integrated to form a complete cultural knowledge system.

3.2. Interface design and background music

Interface design: The system adopts a Chinese-style interface design, including traditional color matching, pattern elements, and layout methods, which not only meets the aesthetic needs of users but also creates a strong cultural atmosphere.

Background music: The system is equipped with traditional background music featuring local characteristics of Shenzhen, such as guzheng and pipa performance pieces from Chaozhou music, or local folk music ensembles of Shenzhen, providing users with a more immersive cultural experience and deepening their appreciation of Shenzhen's traditional culture.

3.3. Function interface

Overview+details: The system presents a digital image overview of cultural products in Shenzhen. Users can quickly understand the visual content of traditional cultural information in Shenzhen through the system's

overview function, including historical background, main features, etc. At the same time, they can also gain a deeper understanding of specific aspects or elements through the detail function, and achieve image focusing and panoramic display through the zoom function.

Navigation+browsing: The system provides clear navigation menus and browsing paths, allowing users to easily find the content they are interested in and explore in depth. There are three forms of experience: timeline browsing, navigation browsing, and free browsing. At the same time, the combination of background music can bring users a visual and auditory experience of being in the context.

Introduction and sharing: For each traditional cultural element or attraction, the system provides detailed introductions and background information, which users can share on social media to share their discoveries and experiences with more people, promoting the dissemination of traditional culture.

4. Practical strategies of traditional culture from the perspective of interactive digital narrative

4.1. Aggregation and integration of data resources

Data resources are the foundation of traditional cultural development. To implement the decision and deployment of the CPC Central Committee on promoting the digital construction of public culture and implementing the digital strategy of the cultural industry, actively respond to the opportunities and challenges brought by the rapid development of the Internet to cultural construction, and meet the growing spiritual and cultural needs of the people, the Office of the CPC Central Committee issued the Opinions on Promoting the Implementation of the National Cultural Digital Strategy. Cultural data has become an important part of the national digital infrastructure. In the digital practice of traditional culture in Shenzhen, the primary task is to extensively collect, organize, and integrate data resources, including various types of cultural resources such as historical documents, cultural relics archives, folk legends, local operas, and folk arts. Through digital means, these resources are transformed into searchable, editable, and interactive digital assets, providing a rich material library for subsequent narrative creation. The aggregation of Shenzhen's traditional culture resources often uses text, images, audio, video, and other methods. To achieve the above goals, it can be based on the ternary framework of "people time events", and collect diverse and heterogeneous data of inheritors, traditional cultural works, local history, and other types based on the time series of traditional cultural inheritance and evolution. By adopting advanced technologies such as big data and cloud computing, a database of traditional culture in Shenzhen should be constructed. The database should have efficient data storage, retrieval, and analysis capabilities, and support cross-platform and cross-terminal data sharing and utilization. At the same time, attention should be paid to data security and privacy protection to ensure the legal and compliant use of cultural resources^[3].

4.2. Extraction and transformation of cultural symbols

Cultural symbols are a key force in understanding and reshaping a place and are the essence of traditional culture. In interactive digital storytelling, how to extract and transform these cultural symbols into modern and attractive narrative elements is the key to achieving innovative dissemination of traditional culture. Firstly, there is a need to develop traditional cultural IP and innovate narrative forms. Shenzhen, located in the south of China, is at the forefront of reform and opening up, with a diverse and vibrant culture. Its intangible cultural heritage resources are equally rich and diverse, including the Shatoujiao Fish Lantern Dance, Hakka Straw Hat Making Technique, Cantonese Opera, and Dapeng Memorial Ceremony for Martyrs, which have distinct regional characteristics.

It has strong regional characteristics. Therefore, based on the rich traditional cultural resources of Shenzhen, a series of cultural IPs with regional characteristics can be developed to create three types of story texts: adapted, extended, and integrated, forming different story worlds. In terms of narrative form, modern literature and film and television works can draw on narrative techniques such as suspense setting and plot reversal to enhance the appeal and influence of the story. Secondly, there is a need to break away from a single narrative mode and construct an intertextual narrative space. In the digital practice of traditional culture in Shenzhen, efforts can be made to construct an intertextual narrative space. Through the interweaving and fusion of various narrative clues, perspectives, and levels, an open, diverse, and interactive narrative environment can be formed to deeply explore the intrinsic value of cultural resources and stimulate users' desire for exploration and participation enthusiasm. Finally, Shenzhen can integrate online and offline derivatives, create IP-related official accounts, make digital facial expression packs, and H5 animations, develop IP-related APPs, and fully integrate IP images into the catering industry, beauty industry, cultural and creative products and toys ^[4].

4.3. Application and development of narrative tools

Narrative tools are important means of achieving interactive digital storytelling. The current development of digital media technology has enriched the means of storytelling. With the increasing maturity of advanced technology, digital media technology integrates various elements such as sound, images, text, animation, and film and television into stories, gradually integrating deeply with traditional cultural development scenarios, giving rise to new formats such as "traditional culture+digital museums", "traditional culture+online tourism", and "traditional culture+electronic games." The Korean Cultural Heritage Agency, SK Telecom, and Google Korea have jointly developed the "ARiran" application to help the public browse the Changde Palace. The public can watch the restricted backyard through VR and enjoy the palace dance "Spring Oriole Dance" through AR [5]. Therefore, in the digital practice of traditional culture in Shenzhen, various narrative tools should also be fully utilized and developed to enhance the interactivity and fun of narration. On the one hand, virtual digital humans can be introduced to achieve human-machine interaction. Virtual digital humans, as an emerging artificial intelligence technology, have been widely applied in multiple fields. In the digital exploration of Shenzhen's traditional culture, researchers can first design a virtual digital human image with unique Shenzhen characteristics, incorporating local cultural elements such as modern urban style and traditional Lingnan culture into its appearance, including clothing and hairstyle. The virtual digital human personality can be designed, and different personalities can be adapted to different narrative scenarios. Secondly, virtual digital humans can be introduced as narrative subjects or guides to interact with users in real time. Through artificial intelligence technologies such as speech recognition and natural language processing, virtual digital humans can understand user instructions and intentions, and adjust narrative rhythm and content based on user feedback. This can enhance the interactivity and personalization of storytelling, providing users with a more authentic experience.

On the other hand, electronic games can be developed to achieve interpersonal interaction. Electronic games, as a highly interactive form of media, have become an important way for young people to obtain information, entertain, and relax. In the digital inheritance of Shenzhen's traditional culture, a series of electronic games that combine Shenzhen's historical background, folklore, and other cultural resources can be developed. These games can be based on Shenzhen's historical landmarks and unique culture as the textual foundation, with Shenzhen's urban landscape as the environmental background, incorporating elements such as Shenzhen's unique service industry and food culture, to create educational and entertaining electronic games. Through game interaction, users

can not only gain a deep understanding of Shenzhen's traditional culture but also share game experiences and enhance friendships with other players, thereby broadening the dissemination channels of traditional culture and attracting the attention and participation of more young audiences.

4.4. Creating an immersive narrative experience through the coexistence of reality and reality

Immersive experience is one of the important features of interactive digital storytelling. In the digital practice of traditional culture in Shenzhen, immersive narrative experiences can be created through the coexistence of reality and virtuality, making users feel as if they are immersed in the world of traditional culture. Firstly, Shenzhen's traditional cultural stories are rich in profound legends, historical tales, and anecdotes of famous people, which are imbued with regional identity and spirit. In narrative creation, the combination of "non-fictional" historical culture and "fictional" artistic creation techniques can form a narrative space where reality and virtuality coexist. By using digital technology to simulate historical scenes, reproduce cultural styles, and incorporate modern aesthetic elements and creative ideas, the narrative content can have both historical weight and a modern atmosphere, triggering emotional resonance among users and inspiring their interest and love for traditional culture. Secondly, virtual reality technology creates a vivid, multi-sensory, and multi-dimensional artificial world, where users can achieve immersive narrative experiences through advanced technologies such as virtual reality (VR) and augmented reality (AR). For example, VR experience zones can be set up in museums or cultural sites in Shenzhen, allowing users to explore virtual historical scenes while wearing VR devices; AR navigation systems can be installed at tourist attractions such as Wutong Mountain, Dapeng Ancient Town, Shenzhen Bay Park, Shenzhen Lotus Hill Park, East China Resort, Window of the World, Splendid China, and Xianhu Botanical Garden, enabling users to scan attraction markers with their mobile phones or tablets to access rich cultural information and interactive experiences. This enhances users' sense of participation and satisfaction and subtly promotes and disseminates Shenzhen's traditional culture ^[6].

In summary, interactive digital storytelling can enrich the presentation of stories and give users more sense of participation and control through the interaction between users and digital content. The practical strategy of traditional culture from the perspective of interactive digital narrative is a systematic project. In the perspective of interactive digital narrative, strategies such as aggregation and integration of data resources, extraction and transformation of cultural symbols, application and development of narrative tools, and creation of immersive narrative experiences through the coexistence of reality and virtuality should be adopted to continuously explore and practice, injecting new vitality and momentum into the development, inheritance, and promotion of Shenzhen's traditional culture, and promoting its brilliance in the new era.

Disclosure statement

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Research on the Influencing Factors for Mental Health Services for the Elderly in the Community in Guilin City

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Abstract: *Objective:* Based on the study of 253 elderly people aged 60 and above in the Guilin community, the scale was used to evaluate their mental health service needs, to analyze and grasp the influencing factors of the psychological needs of the elderly, and the research results will lay a theoretical foundation for improving the overall mental health level of the elderly in China and promoting the healthy development of the elderly in China. *Methods:* The elderly in the Guilin community were selected by a multi-stage stratified random sampling method to meet the exclusion and inclusion criteria, and the local Chinese questionnaire designed by scholars was used to allow the participants to answer the questionnaire. IBM SPSS 22 software was used for data processing and analysis. The one-way ANOVA was performed for each demand dimension, and the difference was statistically significant with $P < 0.05$. *Results:* The highest score was 4.142 for the need for mental health activities, followed by the mean score of 3.822 for the need for mental health files. Univariate analysis showed that there were statistically significant differences in the needs of the elderly with different ages, different living conditions, and different levels of physical health status ($P < 0.05$). *Conclusion:* The elderly have the greatest demand for organizing mental health activities, and the demand for mental health services for the elderly in Guilin is mainly affected by age, residence, and physical health.

Keywords: Population ageing; Older age groups; Community mental health

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1. Introduction

In the 21st century, China is facing a severe problem of population aging. According to the results of the Seventh National Population Census, there are about 264.02 million elderly people aged 60 and above in China, accounting for 18.70% of the total population, and 190.64 million people aged 65 and above, accounting for 13.5% of the total population^[1]. Older people live in a predominantly family-oriented environment, with narrower social ties than before, and are more likely to experience loneliness. In addition, due to the emergence of a variety of chronic

diseases, the elderly are prone to symptoms such as anxiety, fear, and depression without knowing anything about the occurrence and development process of the disease ^[2]. Increasing services for the mental health needs of the elderly in the community, and providing psychological support such as psychological counseling and crisis intervention promptly can not only solve the actual psychological problems of residents but also improve the sense of security and belonging of the elderly group, thereby improving their sense of happiness ^[3].

1.1. Mental health issues in older adults

The elderly population is one of the high-risk groups for mental health problems. Many older adults feel lonely and bored in retirement, lacking a sense of self-worth and belonging, which can lead to depression and other mental health problems ^[4-5]. Moreover, older people often face the effects of factors such as the loss of a spouse or loved one, increased financial burden, and so on, which can have a negative impact on the mental health of older people ^[6-7]. The quality of life of the elderly is one of the priorities of society, and mental health problems will not only affect the personal well-being of the elderly but also have a negative impact on the family and society ^[8]. Therefore, research on the mental health of the elderly can raise public awareness, help the elderly to face the challenges of old age, enhance their self-management ability, and improve the quality of life and happiness of the elderly.

1.2. Geriatric mental health services in Guilin

The United States implements an integrated model with the slogan of “one-stop shopping”, and various mental health service resources are fully integrated, emphasizing all-around and systematic treatment, including medication, psychotherapy, social support, and so on ^[9]. Guilin City, Guangxi, the elderly services are mainly in accordance with the “Guangxi Zhuang Autonomous Region Regulations on Elderly Services” and other documents, the specific measures mainly include support for the construction of elderly institutions, broadening the channels of elderly services, promoting the standardization of the management of elderly services, improving the quality of the elderly service personnel, and the government encourages the support of cultural and sports activities ^[10]. In addition, the “Regulations on Community Health Services” stipulate that community health service institutions shall provide mental health consultation, assessment, intervention, and other services for the elderly, and be equipped with professional personnel ^[11]. In the current regulations and policies, there are clear requirements and support to promote the development of mental health services for the elderly, which provides a more extensive and in-depth guarantee and support for the research on the mental health of the elderly.

Through the study of the mental health service needs of the elderly in the community, this paper can better understand the nature, law, and characteristics of mental health problems of the elderly, which is conducive to promoting in-depth research and development in the field of geriatric psychology. Mental health services for the elderly tend to provide psychological support, but the needs of different groups of older people for psychological support are different. Understanding the psychological needs of the elderly and exploring different types of mental health services can improve the matching degree of psychological services for the elderly. At the same time, it can also provide relevant data and reference for policy-making departments.

2. Methods

The study followed a three-step process to extract and analyze data from the accreditation reports: (1) data sourcing, (2) data cleaning and data extraction, and (3) data labeling and data analysis.

2.1. Data sourcing

Firstly, the research purpose, research object, and research scope were determined, and a questionnaire on the mental health service needs of the elderly was designed based on literature research. To ensure that the questionnaires collected are effectively reflected in the real situation, a pre-survey was carried out before this official survey, and the survey scope was carried out in various communities in Guilin. From the beginning of March to mid-April 2023, using the multi-stage stratified random sampling method, two districts and counties (Xiufeng District and Lingui District) were randomly selected from the central urban area and urban-rural junction of Guilin, and then two urban communities were randomly selected from these two districts and counties, and finally 70 residents were randomly selected from each community, and a total of 280 residential communities were selected as the survey objects. Adopt a combination of centralized filling and decentralized household surveys.

2.2. Data cleaning and data extraction

After the enumerator unifies the standards, patiently explains the purpose of the survey and the requirements for filling in the questionnaire to the residents, and distributes the questionnaire after obtaining consent. For residents with visual difficulties and those who are unwilling or unable to write their responses by hand, the enumerator will read out and explain the contents of the questionnaire to them to record the data.

Before the survey, it was estimated that 280 questionnaires would be distributed and returned, and 253 questionnaires were actually recovered, with an effective recovery rate of about 90.36%. The inclusion criteria for the survey subjects were ≥ 60 years old, urban rather than agricultural hukou, and living in Guilin for more than half a year.

The exclusion criteria are those who fill in the questionnaire involuntarily and those who have a serious physical illness or mental illness and are unable to complete the questionnaire normally. Questionnaire check: complete data double entry and logical error correction, and eliminate invalid questionnaires such as missing answers, not filling in the answers according to the requirements of the instructions, and filling in the logical contradictions of the answer items.

2.3. Data analysis and data labeling

IBM SPSS Statistics 22 software was used for data processing and analysis, and descriptive statistical analysis was used to investigate the demographic structure of the survey sample and the demand analysis of each variable. The one-way ANOVA was performed on the mean score of each demand dimension, and the difference was statistically significant with $P < 0.05$ as the difference.

3. Results

3.1. Survey sample structure descriptive statistics

The survey subjects are the elderly aged 60 and above in the community of Guilin City, and the questionnaire designed mainly investigates the basic information of the elderly, including gender, age group, education level, marital status, residence status, and physical condition. As shown in Table 1, the gender ratio of the survey subjects is more balanced, of which 53% are women and 47% are men, close to the ratio of 1:1. In terms of age composition, there are three main age groups, with 114 of the surveyed elderly people aged 60–69, accounting for about 45%, followed by the age group of 70–79 years old and the advanced age group of 80 years old and above.

3.2. Mental health service needs for older adults

The demand for various mental health services among the elderly in Guilin varies, among which the demand for mental health activities (including geriatric psychological communication activities, elderly educational activities, and communication activities with children) is the largest, with an average value of 4.142 (scores of 1–5, respectively, strongly disagree, not very agree, neutral, agree, and strongly agree), followed by the demand for psychological counseling and counseling services, the demand for mental health knowledge lectures, and the third is the demand for mental health monitoring and mental health service personnel, and the overall demand is “average.” The survey points of the listed demand are above 3, so it can be considered that Guilin must carry out community mental health services for the elderly (**Table 1**).

Table 1. Mental health service needs for the elderly

Service needs	Sample size	Maximum	Mean	Standard deviation
Mental health knowledge lecture service needs	253	5	3.801	0.749
Psychological counseling and counseling service needs	253	5	3.858	0.836
Organizational mental health activity needs	253	5	4.142	0.670
Mental health monitoring needs	253	5	3.731	0.847
Mental health service worker needs	253	5	3.789	0.849

3.3. Analysis of variance of the impact of demographic characteristics on demand

Age had no significant effect on the demand for mental health knowledge lecture services, psychological counseling and counseling, psychological communication activities, and psychological monitoring services, but had a significant impact on the demand for mental health service personnel (P value = $0.022 < 0.05$). The average value was observed to show that the elderly aged 80 and above had the greatest need for mental health service personnel, followed by the elderly in the age group of 60–69 years old, and the least demand for this was the elderly aged 70–79 years, rather than the need for mental health services with age (**Table 2**).

Residence had a significant impact on the overall demand for mental health services for the elderly ($P = 0.008 < 0.05$), which was mainly manifested in the demand for psychological counseling, psychological monitoring services, and mental health service personnel. Older people living alone face a variety of psychological dilemmas due to a lack of close family relationships and social support networks, including loneliness and feelings of loss, as there is no one to share their life experiences or provide emotional support (**Table 2**).

The physical health status of the elderly had a significant impact on the demand for psychological monitoring services and the demand for mental health service personnel (P values were 0.028 and 0.043, both less than 0.05). The average value was observed that the worse the physical condition, the greater the demand for this kind of person because when the physical condition of the elderly is worse, they will face various life challenges and psychological pressures, such as long-term pain, loss of relatives and friends, financial difficulties, feeling helpless, and so on, which will lead to psychological problems such as depressed mood, anxiety, and depression in the elderly (**Table 2**).

Table 2. Impact of demographic characteristics on demand

Variable name	Variable value	Sample size	Mean	SD	F	P
Mental health service worker needs	60–69 years old	114	3.77	0.858	3.866	0.022**
	70–79 years old	76	3.625	0.87		
	≥ 80 years old	63	4.02	0.761		
Counseling and counseling needs	Living alone	79	4.08	0.654	8.378	0.004***
	Not living alone	174	3.757	0.89		
Psychological monitoring service needs	Living alone	79	3.987	0.628	10.913	0.001***
	Not living alone	174	3.615	0.908		
Mental health service worker needs	Living alone	79	3.953	0.72	4.348	0.038**
	Not living alone	174	3.714	0.893		
Psychological monitoring service needs	Healthy	89	3.835	0.903	3.08	0.028**
	1~2 chronic diseases	101	3.538	0.839		
	≥ 3 chronic diseases	53	3.881	0.704		
	Serious illness	10	3.967	0.838		
Mental health service worker needs	Healthy	89	3.764	0.957	2.757	0.043**
	1~2 chronic diseases	101	3.656	0.784		
	≥ 3 chronic diseases	53	4.014	0.699		
	Serious illness	10	4.15	0.952		

Note: *** and ** represent the significance levels of 1% and 5% respectively.

4. Discussion

Mental health needs services for the elderly should follow the principle of individualization. The elderly have different needs for mental health in all aspects of mental health at different ages, physical conditions, and living conditions, and the degree of demand is also inconsistent. Some older people need to focus on their physical health and health care, while others are more concerned about socializing, activities, and recreation, and their needs and values are influenced by the geography and cultural background of the community in which they live. Therefore, it is necessary to provide services on a person-by-person basis, adapting to their needs in a local context.

Older people in their 60–70 years are more concerned about disease prevention, retirement, and family issues, so they can be offered courses and counseling services for health and health insurance. Older people aged 70–80 years are more likely to face physical and cognitive problems and need more physical care and rehabilitation support, as well as social and recreational activities, such as physical exercise, puzzle games, etc., to strengthen communication with the elderly. Older people over the age of 80 face greater health problems and life difficulties, such as the loss of a spouse, hospitalization, and disability, so they need more substantive support and treatment and emotional and spiritual support, for which community care, domestic services, etc., should be strengthened.

When carrying out community health work, it is necessary to grasp the individuality in the commonality, strengthen the management of the physical function of each elderly person, and do a good job in evaluation and monitoring. Formulate a sound mental health monitoring mechanism for the elderly, and pay attention to the living habits, disease conditions, psychological state, and social environment of the elderly in the process of service.

Implement targeted health care and management through health check-ups and follow-ups, and provide timely feedback to prevent and resolve psychological problems.

5. Conclusion

This study analyzed the specific needs of the elderly for mental health services and found that the elderly have the greatest need for organizing mental health activities in terms of overall needs. Among the demand for mental health knowledge lecture services among the elderly in Guilin, the demand for knowledge service lectures on adapting to retirement life is the largest. Among the demand for mental health monitoring services, the need for establishing mental health records is the largest. In terms of the demand for mental health service workers, compared with psychologists, psychiatrists, caregivers, and professional volunteers, the elderly in Guilin may have less need for psychiatrists. The demand for mental health services for the elderly in Guilin is mainly affected by age, residence, and physical health.

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Exploring the Relationship Between Urban High-Rise Residential Areas and the Animalistic Diminishment and Tics in Children from a Pro-Nature Perspective

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Abstract: “Man is directly a natural being” and nature is the natural premise and foundation for human existence. The pro-nature perspective emphasizes the connection between children and the natural environment, and the effective use of natural environments can promote the comprehensive and healthy development of children. In modern society, the contradiction between humans and nature is intensifying, and the survival environment of children is increasingly threatened. This paper, from a pro-nature perspective, delves into the relationship between urban high-rise residential areas and the animalistic diminishment and tics in children, aiming to promote the construction of an ecological civilization city, achieve the comprehensive development of children, and deepen children’s understanding and respect for the natural environment.

Keywords: Pro-nature; High-rise residences; Children; Tics

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1. Introduction

With the acceleration of urbanization in China, an increasing population is gathering in cities, leading to a significant increase in high-rise buildings and a growing number of children living in high-rise residences. Consequently, the adverse effects on children’s health have become more apparent. The reduction of outdoor activities directly leads to animalistic diminishment in children, which in turn triggers the emergence of childhood tics. These issues must be taken very seriously.

2. Pro-nature is a necessity for the comprehensive development of children

Humans are first and foremost natural beings, and the earliest and most fundamental needs are animalistic survival needs or physiological needs of the body ^[1]. Allowing children to enter the natural world can cultivate their emotional connection with their living environment. Through contact with nature, children can gain various authentic experiences. These valuable firsthand, exploratory, and observational experiences not only provide children with spiritual nourishment of beauty but are also very beneficial for the formation of their sound personalities.

Various interesting activities conducted in nature not only bring joy to children but also strengthen their physical bodies, stimulate their imagination, and enhance their hands-on abilities. Research indicates that a 20-minute walk in nature is more beneficial for cultivating children's attention than walking on noisy streets. Some group games can also improve children's social skills, foster their team spirit, exercise their brains, and make them smarter.

Being close to nature highlights the natural qualities in children's growth process, which is also a gesture of respecting life and releasing spirituality. Nowadays, many children are under various pressures during their growth process. Allowing them to be close to nature can greatly reduce their stress and alleviate their anxiety. Undoubtedly, nature is also a vivid classroom for children to acquire knowledge, where they can recognize the infinitely wonderful diverse world. Learning from nature can cultivate children's desire to think and explore, gain various knowledge reserves, and help their future development, laying a solid foundation for their growth.

3. High-rise residences become a barrier between children's growth and nature

According to China's General Principles for Civil Building Design, residential buildings are categorized by their number of floors as follows: one to three floors are considered low-rise residences, four to six floors are multi-story residences, seven to nine floors are mid-high-rise residences, and ten floors or more are classified as high-rise residences. Professor Yin Zhi from the School of Architecture at Tsinghua University stated that the large-scale construction of high-rise residences in China began after the reform and opening up, especially after the implementation of land and housing sales on a paid basis. The peak of high-rise residential construction started around the late 1980s, primarily due to technological advancements and the severe housing shortage at the time.

It is undeniable that the towering buildings that rise in cities have become a barrier for children to access nature. Many high-rise residences are enclosed or semi-enclosed, leading to an increase in the time children spend indoors. Due to limitations in ventilation, this can result in the retention and accumulation of indoor radioactive pollutants. Studies by foreign scholars have shown that children living in high-rise residences for extended periods are more likely to develop various negative personality traits compared to children living in bungalows who have more contact with nature. The higher the building, the more severe this situation becomes ^[2].

Physical health is the foundation of children's growth. The rapid urbanization has already brought adverse effects on children's health due to the changes in residences. The lack of outdoor public spaces and community environments has led to a decrease in children's outdoor activities. Currently, domestic high-rise residential communities generally lack naturalized, child-scale experiential facilities. Building a more authentic and wild city, bridging the gap between children and nature, reestablishing the connection between children and nature, and providing children with more natural public spaces has become an urgent issue to be addressed in urban construction ^[3].

4. Distance from nature leads to animalistic diminishment in children

From a physiological perspective, children retain various “animalistic” instincts and qualities, which are clearly manifested in their daily behaviors and participation in games. A wealth of anthropological and zoological research indicates that the learning method shared by children and small animals is play. Before the advent of written language, education and the transmission of various knowledge and experiences to children could be conducted through play ^[4]. It is evident that allowing children to have ample time and space to engage in nature-oriented games and activities is beneficial for maintaining their animalistic characteristics.

It is important to be vigilant that children confined to high-rise residences become overly reliant on electronic products, spend long periods sitting, stay away from natural environments, reduce social interactions, and gradually lose their innate desire to move, which in turn manifests as a weakening of their animalistic traits. Survey data indicates that children living in high-rise residences lag significantly behind those in low-rise areas in terms of height and lung capacity. Through family factor investigations, it has been found that the main reason for the developmental lag in children living in high-rise residences is the lack of outdoor nature-oriented activities and physical exercise ^[5].

The relationship between humans and nature is one of the most fundamental issues in the world. Allowing children to live a pro-nature life and retain necessary animalistic characteristics plays a positive role in correctly addressing the increasingly severe ecological problems facing humanity. The objective natural world is continuously developing, and human cognitive activities must keep pace with the progress of the times. While economic development is emphasized, it is essential to pay attention to the object relationship of mutual affirmation between humans and nature, which is unchanging. While people stress the importance of human transformation of nature, they must also recognize that nature will have a counter-effect on humans. Allowing children to retain necessary animalistic characteristics in a pro-nature life is precisely for achieving harmonious development between humans and nature and the comprehensive development of children.

5. Insufficient exercise becomes a trigger for childhood tics

The sense of enclosure in high-rise residences can bring a sense of loneliness to the children living in them. Research indicates that children who live for extended periods in high-rise residences may develop an involuntary hostility towards themselves and the world, and their intellectual development can also be somewhat hindered. High-rise residences are also an undeniable trigger for children’s diseases ^[6]. Currently, the number of children in China suffering from tics is on the rise, with approximately 1.8 to 3.96 million children troubled by this condition, and about 360,000 new cases each year, a number that continues to increase annually. Tics are a common psychiatric disorder in children, with a variety of causes and locations of onset. A poor living environment is one of the key driving forces behind children developing tics ^[7]. Encouraging children to engage in appropriate nature-oriented activities can relax their minds and bodies, strengthen their physical constitution, and greatly aid in the prevention and treatment of childhood tics. Studies have shown that outdoor activities and group games are effective ways to combat childhood tics. Children living long-term in high-rise residences, surrounded by electronic products, are not only negatively impacted by their vision but also predisposed to developing tics. Outdoor nature-oriented activities can divert children’s attention, thereby reducing tic symptoms. Group activities can also boost children’s confidence and happiness, as a positive mood is the best weapon against tics. Stress can exacerbate the symptoms of tic patients, and nature is the best stress-relieving environment. Being close to nature

undoubtedly reduces the symptoms of childhood tics.

A professor from the University of Tokyo has concluded from long-term observation that living in high-rise residences is detrimental to the growth and development of children^[8]. According to a report released by the World Health Organization (WHO), the proportion of Chinese children and adolescents who are physically inactive ranges from 80% to 89%. The situation is even more severe for children living in high-rise residences, which has become a contributing factor to the development of tics in some children. Childhood tics often manifest as recurrent, non-rhythmic, involuntary movements, such as frequent blinking, eye squinting, involuntary head shaking, leg shaking, and so on, accompanied by involuntary vocalizations and changes in behavior. In severe cases, there may be sleep disturbances, obsessive-compulsive symptoms, and tendencies toward self-harm or self-injury^[9]. Therefore, all sectors of society must pay attention to the harm that physical inactivity can cause to children's health.

6. Recommendations and prospects

Ecological cities, as a new urban development concept, primarily aim for harmonious coexistence between humans and nature, using ecological protection and development as means, and advocating for the adherence to natural laws in urban construction^[10]. With the increasing number of high-rise residences in cities, it is necessary to conduct more research on the relationship between high-rise residences and children's health, providing references for the development of ecological cities. Parents living in high-rise residences should encourage their children to participate in nature-oriented activities by going outside, improving children's physical fitness, and combating the occurrence of various diseases. Children are the future of the city, so the construction of modern cities should not come at the expense of children's health. Overall, there are still many deficiencies in China's research on children's living spaces, with a lack of research data, which all require continuous attention and further in-depth exploration by relevant individuals.

Disclosure statement

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Temporal and Spatial Changes of NDVI and Soil Erosion in Ningxia Grassland Before and After Grazing Ban

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Abstract: Grassland is an important part of the ecosystem, which plays a good role in soil and water conservation. The degradation of grassland is easy to cause soil erosion in related areas. The reason is that overgrazing makes the grassland degrade rapidly. Ningxia has introduced a policy to ban grazing on natural grasslands, which can effectively safeguard grassland ecology, improve the condition of grasslands in Ningxia, and reduce the risk of grassland loss. This paper mainly analyzed the vegetation dynamics and soil erosion of grassland in Ningxia, and explored the changes before and after the grazing ban, to accumulate experience for ecological management.

Keywords: Grazing ban; Grassland vegetation dynamics; Soil erosion

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1. Introduction

Soil erosion can be divided into two main types: hydraulic and wind. Wind erosion and desertification are easy to cause soil nutrient loss, and eventually evolve into land degradation. Among all ecosystems, compared with other systems, the grassland ecosystem has obvious wind erosion resistance, which can play the wind and sand fixation value of grassland vegetation. Grassland vegetation has the value of intercepting sand grains, optimizing soil material composition, effectively inhibiting the erosion caused by wind and sand, and has a good effect on wind and sand prevention. At the same time, grassland also has the function of soil and water conservation, which can effectively protect soil and water resources. Grassland vegetation can cover the ground and grow close to the ground, which can block precipitation, effectively reduce surface runoff, and reduce water evaporation. On the other hand, grassland vegetation has a relatively developed root system with vertical and horizontal roots, which can effectively improve soil permeability.

2. Overview of nature in Ningxia

There are 12 types of grassland in Ningxia Province, which can be divided into 3 heat levels: cold temperature, mild warm, and mild warm; There are 5 wetness levels: slightly dry, arid, humid, and so on. The grassland type in the region is mainly semi-desert grassland, which is divided according to Ningxia region. The north of Ningxia is warm and wet grassland. In the middle of Ningxia, the grassland is mild and dry. The actual vegetation coverage was insufficient and the grass layer was sparse^[1]. The temperate humid grassland and typical grassland are mainly found in the south of Ningnan.

In addition, there are roughly 24 soil types in Ningxia, and yellow soil is relatively large, accounting for about 28.33% of Ningxia's land area. The second soil type is lime-calcic soil, accounting for 26.79% of Ningxia's land area. The other soil types in Ningxia include aeolian sand, gray-brown soil, holloessian soil, and red clay, accounting for 3% to 11%. From the regional level, the Liupan Mountain and Helan Mountain are mainly distributed in Ningxia^[2]. The aeolian sand is mainly distributed in the Lingyan Platform near the Mu Us region and northwest Zhongwei near the Tengger Desert. Irrigated silt is mainly distributed in Ningxia and Zhongning plains. Lingyan Plateau has been affected by the activities of clearing land and overgrazing for a long time, which has accelerated the pace of soil desertification. Because of the high wind power and relatively dry climate in this area all year round, it is the most widely distributed area of wind-blown sand in Ningxia^[3]. In the northern arid region of Ningxia, the main soil types are lime-calcium soil, aeolian sand soil, and red clay, while the central region is salt soil, yellow spongy soil, and so on.

3. Spatial-temporal changes and driving forces of NDVI in Ningxia grassland before and after grazing ban

3.1. Changes in NDVI spatial pattern of grassland

According to **Figure 1**, it is not difficult to find that from the perspective of grassland cover types in Ningxia, combined with the conversion of grassland cover types at the same level, the proportion of grassland cover types decreased by 12.54% after the grazing ban. Among them, from 1988 to 2018, 44.23% of the areas with unchanged grassland cover were in Ningxia. Combined with the advanced conversion of grassland cover types, the proportion of Ningxia after the grazing ban increased by 10.56% compared with before. From 1988 to 2018, the proportion of advanced conversion of grassland cover was 54.54%, which developed into a positive evolution^[4]. Before the grazing ban, the conversion of grassland type to advanced grassland type was mainly located in northwest Ningxia, and the path was from low cover to low cover grassland, accounting for 12.65%. The development of low-cover grassland was medium-cover grassland, and its path accounted for 9.59%^[5]. After the actual grazing ban, the advanced grassland type conversion was mainly located in the southern, central, and eastern regions of Ningxia, and the main path was the development from low-cover to medium-cover grassland, accounting for 29.94%, which significantly optimized the ecological environment^[6]. Combined with the low-level conversion of grassland cover type, the proportion after the grazing ban increased by 2% compared with that before the grazing ban. The low-level conversion after the grazing ban was mainly in the range of medium-cover to low-cover grassland, accounting for 2.73%.

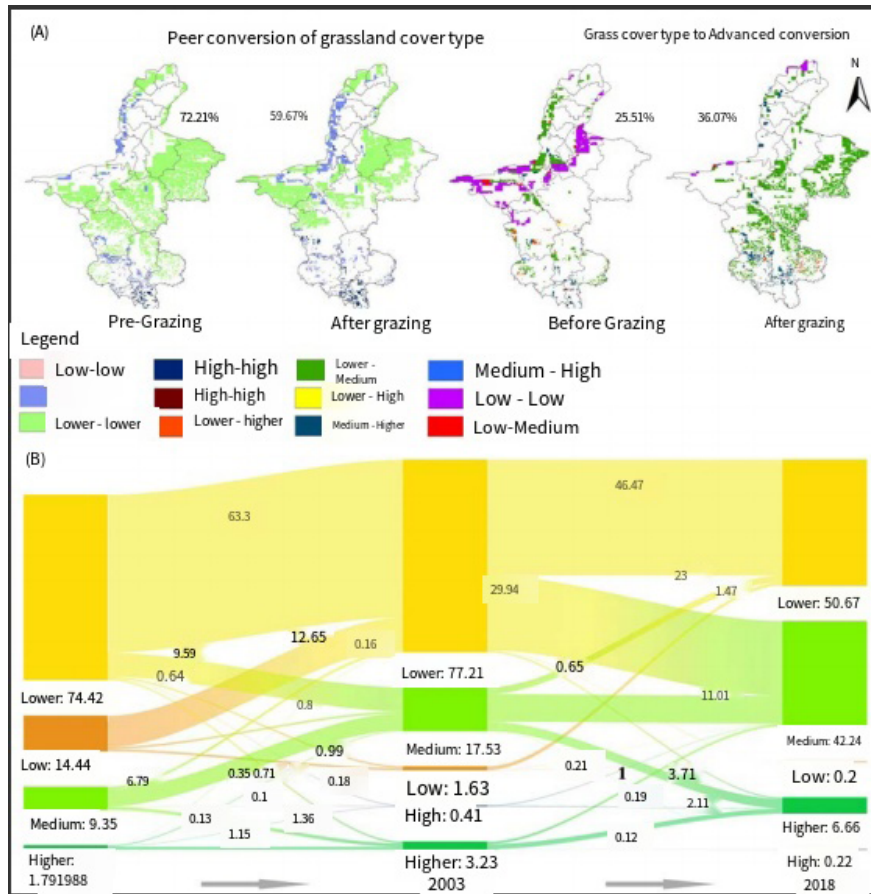


Figure 1. Spatial distribution of grassland cover transfer in Ningxia

3.2. NDVI driving forces of grassland in Ningxia before and after grazing ban

3.2.1. Effects of human activities on grassland NDVI

Human activities affect NDVI and carry out analysis activities by supporting the trend of residual difference. Before the grazing ban in Ningxia, the residual value increased rapidly from 1988 to 1994 and decreased from 1994 to 2002. In the above stages, most of the effects of human activities on NDVI were negative ^[7]. After that, the negative effects of human activities decreased significantly and gradually changed into positive effects. There was little change in the residual value before and after the ban on grazing in Ningxia. After the grazing ban, the influence of human activities fluctuated, and most of the residual values in this period were positive, indicating that human activities in this period had effectively improved the grassland cover ^[8]. Specifically, human activities had an improvement effect on NDVI, which showed an increasing trend during 1988–1994, and the fluctuation of residual value gradually increased during 2002–2018. According to the actual situation of Ningxia, the proportion of NDVI increase promoted by human activities before the grazing ban reached 66.25%, and the main distribution area was the central region. After the grazing ban, the area of NDVI decreased due to human activities increased by 21.51% compared with that before the grazing ban, mainly in the central region ^[9]. In conclusion, during 1988–2018, human activities contributed to the increase of NDVI, which accounted for 88.41%, and distributed in most areas of Ningxia.

3.2.2. Relative contribution of driving force to NDVI of grassland

The relative contribution of driving force to grassland NDVI was based on multiple linear regression and residual analysis. It can be combined with NDVI changes to distinguish them, including improvement area and degradation area, which effectively shows the contribution of climate change and human activities to grassland. In the NDVI improvement area of grassland, the proportion of areas affected by climate change and human activities from 1988 to 2018 was 49.98% and 56.17%. After the grazing ban, the contribution of climate change increased by 8.84%, while the contribution of human activities decreased by 18.85% ^[10]. Based on the decreased area of NDVI, the main influencing factor of NDVI from 1988 to 2018 was human activities, which accounted for 73.68% of the total area, and 85.39% and 93.04% of the total area before and after the grazing ban in the process.

4. Analysis of water erosion of grassland in Ningxia before and after the grazing ban

4.1. Increasing soil erosion of grassland

Soil erosion is the result of the joint action of surface, climate, and soil ^[11]. The spatial distribution of soil erosion is often affected by terrain, soil, and other factors, and the different terrain characteristics are mainly regional characteristics of local climate, soil, and vegetation.

The change in climate is mainly combined with the change in precipitation and temperature, which directly affects the effect of soil erosion. Due to the emergence of global warming, the global climate is constantly changing, in which hydraulic erosion increased by 2.3%, with the most obvious impact in semi-arid areas ^[12]. On the one hand, global warming has an impact on the water cycle ^[13]. On the other hand, as global warming increases land runoff, rising temperatures and decreasing precipitation promote the increase of river sediment transport and discharge. According to the factor detection, it is found that the explanatory power of temperature is third place after slope and elevation in different periods except Liupanshan area. After the grazing ban was implemented in Ningxia, the interaction between the ecological security barrier and the temperature and slope of the extension area in the Luoshan and Helan Mountains was improved. The main cause of soil erosion is high-intensity rainfall, in which a 20% increase in precipitation will increase water erosion by 37%. In the display of interaction, temperature and precipitation played a good interaction in the Liupan Mountain area ^[14]. According to the study of Ningxia, the erosion reached its maximum value when the annual precipitation increased to 200–400mm. When the average precipitation reaches about 300mm, the grassland erosion in Ningxia shows strong characteristics.

The relationship between soil erosivity and soil chemical and physical structure is close. The permeability of silt particles is weak, and it is easy to cause water erosion. The clay particles have the characteristics of anti-stripping, and the permeability of sand particles is stronger, which can effectively reduce the function of raindrops. The development of unreasonable human activities will lead to the destruction of soil structure the reduction of soil organic matter, and the lack of stability of aggregates. In the ecological security barrier and extension area of the Luoshan area, the content of soil organic matter is insufficient, and the content of sand is high, with the highest value of 90%. In the Liupanshan area, the soil erodibility is high, the sand content is low, and the silt content is high, accounting for 54%. Based on these soil conditions, this region has become an area of frequent water erosion in Ningxia.

4.2. “Banning grazing” effectively reduces the risk of net erosion

Proper grazing can help reduce soil erosion in grasslands. In grassland areas with proper grazing activities, animal hooves have a trampling effect on the soil, which is not enough to destroy the soil structure of the grassland.

Compared with degraded cultivated land, proper grazing can increase the soil bulk density^[15]. The increase in soil volume can also reduce soil erosion to a certain extent. Overgrazing, however, will reduce the vegetation cover and permeability of grassland, and increase the probability of soil erosion. In addition, overgrazing reduces the roots of grassland vegetation which stabilizes the soil structure, thus intensifying soil erosion.

In the context of the current era, Ningxia has introduced a series of grassland ecological protection policies, focusing on the practice of banning grazing and confining breeding and implementing ecological projects to return grazing to grassland. In 2011, Ningxia officially promulgated the regulations on banning grazing and flocking, after which the level of change trend in Ningxia increased slowly as the main body. The proportion of grassland vegetation with medium coverage increased by 16.15%, distributed in the mountainous area of southern Ningxia and the west side of Ningxia Plain, among which Wuzhong City, Tongxin County, and other eastern areas of Ningxia effectively adjusted the ecological environment. The contribution of precipitation to the reduction of net erosion risk was negative. Although the precipitation increased in this stage, the net erosion risk was theoretically increased, but the impact of human activities, such as the grazing ban, resulted in the net erosion risk being reduced. When the NDVI value exceeds 0.6, no matter what the slope level is, the net erosion rate is subject to slight and mild erosion. In the above situation, banning grazing and restricting natural grassland can restore grassland vegetation, effectively reduce soil erosion caused by slope and other factors, and effectively maintain soil and water. Through the study of the temporal and spatial changes of grasslands before and after the grazing ban, soil erosion of grasslands in Ningxia can be accurately estimated. The factors can be clarified to provide academic and scientific support for the subsequent grassland management practice.

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On Ancient Driving Techniques

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Abstract: Driving techniques are a fundamental aspect of the transportation sector, influencing both the operational efficiency of transportation systems and the broader social and cultural landscape. In ancient China, transportation systems displayed distinct characteristics shaped by the terrain and cultural diversity. The development of ancient driving techniques was not only a means of mastering space but also a reflection of social systems, technological advancements, and the progression of civilization. Through in-depth research on these techniques, researchers can gain insights into the development context of ancient society and understand the profound impact of its transportation system on cultural exchanges and social evolution. By thoroughly understanding their development and impact, it reveals the evolution trajectory of the ancient social transportation system and triggers reflections on their far-reaching influence on society, culture, and technology. Meanwhile, this paper will introduce the types of ancient transportation vehicles, the skill requirements, and the training methods of drivers.

Keywords: Ancient driving techniques; Transportation vehicles

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1. The origin and development of ancient driving techniques

1.1. Review of the development process of transportation in ancient China

The origin of ancient driving techniques can be traced back to the Neolithic Age when people mainly relied on walking and the strength of animals for movement. With the development of agriculture and population, the demand for transportation vehicles gradually increased. In the early days, people mainly relied on walking, horseback riding, and driving carriages. One of the earliest transportation vehicles was the horse-drawn carriage. Merchants were among the first to drive horse-drawn carriages. The Shang tribe was a migratory nation. During the pre-Shang period, they had migrated 8 times, and after the founding of the state, they moved the capital 5 times. The Shang people were also a nation good at doing business, and doing business required constantly traveling to places far away from their homeland for trade ^[1]. After a series of developments, the status of horse-drawn carriages continued to rise. Around the 16th century BC, large horse-drawn carriages in the Shang Dynasty gradually became a symbol of the aristocratic society. Over time, carriage driving became more and more popular,

and the structure and design of vehicles were gradually improved. By the Warring States period, more elaborate four-horse-drawn carriages emerged.

1.2. The origin and inheritance of ancient driving techniques

During the reign of Qin Shi Huang, a driving trend emerged, which developed into a series of driving traditions. The horse keeper in the Qin State wore special armor and required four years of training to drive. At the same time, the examination consisted of five driving skills, with strict requirements not only for techniques but also for their behavior and etiquette. Those who failed would pay a huge price and were not allowed to take the exam again.

The inheritance of ancient driving techniques was mainly carried out through family and master-apprentice systems. This inheritance method focused on both the techniques and education in various aspects such as culture and etiquette. There were detailed norms on chariots and horses in the *Rites of Zhou* ^[2].

1.3. The development of ancient driving techniques in vehicles and road construction

Ancient driving techniques were also developed in road construction. To adapt to vehicles, some important roads were improved and built. For example, as for the *Qinzhidao*, it “connected Jiuyuan and Yunyang. Mountains were cut through and valleys were filled in to build this straight road. The road was fifty paces wide, with trees planted every three zhang (a unit of length in ancient China). Its outer sides were thickly built up and rammed solid, and then hidden with metal awls, and pine trees were planted along it” ^[3]. In addition, the construction of some important roads and commercial routes also promoted the development of transportation and driving techniques.

Driving techniques development in ancient China largely promoted social exchanges and economic prosperity. People of different classes such as nobles, merchants, and officials all relied on drivers and vehicles for movement.

Through the continuous evolution and inheritance of driving techniques, transportation in ancient society was improved, laying the foundation for the development of economy, culture, and society. These ancient experiences and traditions have positive implications for our understanding of the evolution and development of modern transportation systems.

2. The driving techniques of ancient transportation vehicles

2.1. The types and characteristics of ancient transportation vehicles

There were various ancient vehicles, such as horse-drawn carriages, boats, sedans, etc., with unique driving techniques and characteristics. All of them played important roles in transportation and communication, and their driving techniques were of great significance in that society.

2.1.1. Horse-drawn carriage

The horse-drawn carriage was one of the important land transportation in ancient times. Its types included the four-horse-drawn carriage, the six-horse imperial carriage, and so on. The four-horse-drawn carriage was pulled by four horses and was a symbol of class. Different classes had different numbers of horses. As recorded in *Wang Du Ji*, “The emperor was drawn by six horses, the feudal lords by five, the ministers by four, the high officials by three, the scholars by two, and the common people by one” ^[4]. The horse keeper needed to be proficient in handling horses, master vehicle control skills, and understand etiquette and communication skills to adapt to the cultural requirements of the aristocratic society.

2.1.2. Boat

There were diverse rivers in ancient China, and boats played an important role in water transportation. According to *History as a Mirror*: “Wang Zhen’e led the naval forces to enter the Wei River from the Yellow River and then marched towards Chang’an...Wang Zhen’e’s troops sailed upstream along the Wei River on small warships called ‘Mengchong’. The rowers were all inside the warships. When the people of the Qin State saw the warships moving forward but could not see the rowers, they were all astonished and regarded them as divine troops”^[5]. The earliest recorded boat appeared in the Eastern Jin Dynasty and was mainly used in warfare. Its types included rowing boats, sailing boats, dragon boats, and so on.

2.1.3. Sedan

The sedan was a common transportation vehicle in the ancient aristocratic society and was used for the travel of nobles or wealthy merchants. According to *the Books of History* and *Records of the Grand Historian*, the sedan has a history of thousands of years in China. The driver was usually called a sedan-bearer, who needed to possess balance skills and good physical fitness to ensure a smooth journey.

2.2. The skill requirements and training methods of ancient drivers

Ancient drivers usually referred to those who drove horse-drawn carriages or other vehicles. The skills and training methods varied depending on the era and region. Generally speaking, they needed to master the skills related to driving the corresponding vehicles, understand road conditions, and safety knowledge. The training methods might include learning from masters, accumulating practical driving experience, and the way of oral instruction and personal demonstration.

2.2.1. Horse keeper

The horse keeper needed to have the skills to control horses, including understanding the personality characteristics of different horses and being good at taming and commanding horses. They also needed to master vehicle control skills and take correct countermeasures in emergencies. The training method was mainly through practical driving operations, and the traditional family inheritance and master-apprentice system were the main training channels.

2.2.2. Boatman

The boatman needed to understand the structure and performance of the boat, be familiar with natural environments such as water currents and tides, and possess boat handling and navigation skills. The training method included operating training in actual water areas, usually with experienced boatmen passing on their experience. In addition, boat drivers also needed to learn how to deal with unexpected situations, such as sudden wind and wave attacks or boat failures.

2.2.3. Sedan-bearer

To ensure the safety and comfort of passengers, the sedan-bearer needed to have the skills of walking steadily and a strong physique. They also needed a lot of training before taking up the job. The traditional training methods included the personal guidance and demonstration of the master and gradually becoming familiar with the technical essentials in actual driving operations.

2.3. The role and impact of ancient driving techniques in transportation

Ancient driving techniques played an important role in transportation. Excellent driving techniques could improve the utilization efficiency of vehicles and also provide feedback for their design and improvement, promoting continuous innovation and progress. The transportation system in ancient society largely depended on the technical level of drivers, and its development also laid the foundation for later transportation vehicles and systems.

2.3.1. Improving transportation efficiency

Ancient driving techniques had a significant impact on transportation efficiency. First, advancements in driving skills allowed for more precise control of vehicles, increasing transportation speed. Second, skilled drivers enhance the stability and speed of vehicles, further boosting efficiency. The improvement of these techniques facilitated the exchange of goods and movement of people and thus played a key role in promoting social development.

2.3.2. Spreading etiquette and culture

Drivers in the aristocratic society were not only the drivers of vehicles but also the spreaders of culture and etiquette. They needed to be familiar with social etiquette and understand the skills of interacting with people of different classes, contributing to the inheritance and development of the entire social civilization.

2.3.3. Maintaining traffic safety and social order

Skilled driving techniques helped reduce the occurrence of traffic accidents and maintain social order. In the Qin Dynasty, Qin Shi Huang had already promulgated traffic laws ^[6]. There were also clear traffic rules in the *T'ang Code* ^[7].

3. The role of driving techniques in ancient traffic safety

3.1. The causes and frequency of ancient traffic accidents

In ancient times, limited transportation vehicles and poor road conditions led to a high frequency of traffic accidents. The technical skill of drivers directly influences vehicle control and their ability to handle emergencies. Uneven roads and the absence of traffic signs made driving more difficult, while mechanical failures of vehicles also posed a risk of accidents.

3.2. The role of ancient driving techniques in improving traffic safety

The role of driving techniques in ancient traffic safety was mainly reflected in the following aspects.

First, good driving techniques helped reduce the occurrence of accidents. Ancient drivers needed to have a proficient grasp of transportation vehicles, be familiar with road conditions, and be sensitive to the surrounding environment, so that they could detect potential dangers in time and take effective measures.

Second, driving techniques were also crucial for dealing with accidents. Ancient society lacked modern rescue equipment, and drivers needed to have certain first aid and self-rescue skills after an accident.

3.3. The application of ancient driving techniques in traffic management and accident response

In ancient society, driving techniques also played an important role in traffic management. Traffic management involved aspects such as road planning, intersection settings, and traffic signs, and the understanding and

compliance of drivers with these rules and signs were crucial for maintaining the overall traffic order. In 1973, the dossier of a traffic accident case tried by the local government in the Tang Dynasty was unearthed from the Astana Ancient Tombs in Xinjiang, uncovering a car accident more than a thousand years ago and providing the most direct information for researchers to understand the trial procedures and punishment principles of ancient traffic accident cases^[8]. Therefore, since ancient times, drivers who did not follow traffic rules and traffic orders would be punished.

4. The impact of ancient driving techniques on modern traffic culture and techniques

The past influences the present, driving progress. The invention of gunpowder marked the shift from the era of cold weapons to gunpowder-based weapons, gradually replacing chariots and warhorses with guns and tanks. Similarly, ancient driving techniques have deeply influenced modern traffic culture and techniques.

Firstly, ancient driving culture and etiquette have shaped modern traffic rules, such as yielding to pedestrians and obeying traffic signals.

Secondly, the legacy of ancient driving techniques has laid the foundation for modern driving. Despite changes in transportation vehicles and technologies, the core principles and skills of driving remain, with ancient drivers' environmental awareness positively influencing the technical skills of modern drivers^[9].

4.1. The modernization challenges of the value of ancient driving techniques

4.1.1. The inheritance of ancient driving techniques faces modernization challenges

With technological advancements and the continuous evolution of transportation vehicles, modern driving techniques have developed new characteristics. While traditional techniques hold historical value, they must be integrated with modern technology to address the complexities of today's traffic and advanced vehicles.

The inheritance of ancient driving techniques significantly shaped the traffic culture and technology of ancient societies and continues to influence modern developments. However, the challenges of preserving and modernizing these techniques require careful attention to ensure their ongoing evolution.

4.1.2. Emphasizing the importance and traditional value of ancient driving techniques

As technology and society evolve, traditional driving techniques struggle to meet the demands of modern traffic and advanced vehicles. This paper suggests the following areas for further research.

First, researchers should investigate the inheritance issues of ancient driving techniques, analyze their relevance to modern transportation, and propose improvements.

Second, the impact of ancient driving techniques on modern driving culture and traffic norms can be studied, focusing on their practical significance and impact on driver quality in modern society.

Finally, the integration of ancient driving techniques and modern technology can be explored. With the progress of technology, modern transportation, and driving techniques are also evolving. Combining traditional techniques with modern technology to enhance transportation efficiency and safety is a key area for future research.

5. Conclusion

In summary, ancient driving techniques were crucial to the development of transportation and social civilization.

By studying their methods, characteristics, and societal impact, researchers gain a deeper understanding of ancient transportation systems. Facing modern challenges, researchers should preserve traditional values while advancing with the times, promoting the progress of both transportation technology and culture. Transportation is an important way for people to interact and is a manifestation of the spatial and temporal changes in social development ^[10]. Now, unmanned driving technology has emerged, and there will be more challenges and opportunities in the future.

Disclosure statement

The author declares no conflict of interest.

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Efficient Photocatalytic Degradation of Tetracycline with Hydrothermally Synthesized Pure-Phase BiFeO₃

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Abstract: Tetracycline pollution poses an increasing global threat to both aquatic and terrestrial biodiversity due to its extensive use in aquaculture, livestock farming, and human disease prevention. In this study, pure-phase BiFeO₃ was synthesized using the hydrothermal method. Various characterization techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), and X-ray photoelectron spectroscopy (XPS), were employed to analyze the material's crystal structure, surface morphology, and electron valence states. A 120-minute photocatalytic degradation experiment on tetracycline (TC) demonstrated that the pure-phase BiFeO₃ achieved a degradation efficiency of approximately 27%. The primary degradation mechanism was attributed to the generation of •OH (hydroxyl radicals) during the photocatalytic reaction, with h⁺ (holes) playing a synergistic role. The energy band structure and photocatalytic mechanism of pure-phase BiFeO₃ were further analyzed using Ultraviolet-visible spectroscopy (UV-VIS-DRS). Cycling tests indicated that pure-phase BiFeO₃ maintained chemical stability, highlighting its potential for large-scale applications.

Keywords: Pure-phase BiFeO₃; Tetracycline degradation; Photocatalytic efficiency; Mechanism

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1. Introduction

Tetracycline (TC), a widely used synthetic antibiotic, is commonly employed in treating various diseases in both humans and animals. While they effectively inhibit protein synthesis in bacteria, their widespread use has led to significant environmental pollution^[1-2]. Among various treatment methods such as Fenton processes, ozonation, UV photolysis, and sonolysis, advanced oxidation processes (AOPs) have been developed to address the inefficiency of conventional methods in removing TC antibiotics from wastewater^[3-4]. Among AOPs, photocatalysis stands out due to its strong redox ability, low cost, long durability, and resistance to adsorption saturation. These attributes make it a promising solution for scalable wastewater treatment aimed at degrading

micropollutants, and producing low toxic intermediates ^[5–6]. Commonly used photocatalysts like TiO₂ have limitations, including low efficiency under visible light and rapid recombination of photon-generated electron-hole pairs, which reduce their effectiveness in practical applications ^[7].

Bismuth ferrite (BiFeO₃, BFO) has emerged as a highly promising photocatalyst for the degradation of tetracycline (TC) due to its unique properties. Unlike TiO₂, which primarily responds to ultraviolet light due to its wider bandgap, BiFeO₃ exhibits a narrow bandgap (2.0–2.6 eV), enabling it to harness visible light and greatly enhancing solar light absorption efficiency. This makes BiFeO₃ particularly advantageous for real-world applications where visible light constitutes a significant portion of the solar spectrum. Additionally, the distortion of the lone-pair Bi 6s orbitals in these bismuth-based complex oxides facilitates the overlap between the O 2p and Bi 6s orbitals in the valence band, enhancing the migration of photon-induced charges and significantly improving photocatalytic efficiency. Numerous studies have demonstrated the visible light-driven photocatalytic activity of BiFeO₃ in the degradation of organic pollutants ^[8–9].

2. Experimental section

2.1. Preparation of pure-phase BiFeO₃

To prepare pure-phase BiFeO₃, different samples were synthesized using the hydrothermal method: First, 5 mmol of Bi(NO₃)₃·5H₂O and 5 mmol of Fe(NO₃)₃·9H₂O (1:1 stoichiometric ratio) were added to the inner liner of a 25 ml hydrothermal reactor. Then, 18 ml of 8 mol/L KOH solution was added, and the mixture was stirred magnetically for 30 minutes. The reactor was sealed tightly and placed in an oven at 180°C for 6 hours, with a ramp-up time of 80 minutes and a cooling time of 800 minutes (heating rate of 2°C/min and cooling rate of 0.20°C/min). After the reaction, the product was filtered and washed three times with deionized water and anhydrous ethanol and then dried naturally. This material was named BFO-1. Similarly, 2.5 mmol of Bi(NO₃)₃·5H₂O and 2.5 mmol of Fe(NO₃)₃·9H₂O (1:1 stoichiometric ratio) were added to the inner liner of a 25 ml hydrothermal reactor. The same procedure was followed, with the addition of 18 ml of 8 mol/L KOH solution, magnetic stirring for 30 minutes, sealing, and heating in an oven at 180°C for 6 hours. The product was filtered, washed, and dried as previously described, resulting in the material named BFO-2. In another variation, 5 mmol of Bi(NO₃)₃·5H₂O and 5 mmol of Fe(NO₃)₃·9H₂O (1:1 stoichiometric ratio) were used with 18 ml of 6 mol/L KOH solution. The same hydrothermal procedure was followed, and the final product, after filtering, washing, and natural drying, was named BFO-3.

2.2. Characterization

X-ray diffraction (XRD) was performed with a Bruker D8 Advance diffractometer, utilizing Cu K α radiation ($\lambda = 1.5406 \text{ \AA}$) to determine the crystal structure. The morphologies of the photocatalysts were analyzed using scanning electron microscopy (SEM) with a JEOL-7800F ZEISS and high-angle annular dark-field scanning transmission electron microscopy (HAADF-STEM), along with X-ray energy dispersive spectroscopy (EDX) for elemental mapping using a JEOL-2100F. The surface composition and oxidation states of the samples were analyzed via X-ray photoelectron spectroscopy (XPS) with an ESCALAB 250XI instrument. UV–vis diffuse reflectance spectra were recorded in the range of 200–800 nm using a Hitachi UH4150 spectrophotometer.

2.3. Photocatalytic performance test

The photocatalytic reaction was conducted in a quartz vessel using a 300 W xenon lamp equipped with a 420 nm

cut-off filter to block UV light. The vertical distance between the lamp and the reaction vessel was maintained at 15 cm. To prevent thermal effects on the results, the quartz vessel was cooled by circulating water, ensuring the temperature remained at room temperature. During the photocatalytic process, 50 mL of a tetracycline solution with a concentration of 20 mg/L was introduced into the quartz vessel, followed by the addition of 20 mg of catalyst powder. Continuous magnetic stirring was applied to ensure uniform dispersion of the catalyst in the solution. Before initiating the reaction, the mixture was stirred in the dark for 30 minutes to achieve adsorption-desorption equilibrium between the catalyst and the tetracycline molecules. Subsequently, 3 mL samples were collected at 30-minute intervals under light irradiation. The catalyst powder was separated from the solution using high-speed centrifugation. The absorption spectra of the collected samples were recorded using a UV-2450 spectrophotometer over the wavelength range of 200-800 nm. The degradation rate was calculated using the following formulas ^[23].

$$\text{Degradation}(\%) = (C_0 - C_t / C_0) \times 100\% = (A_0 - A_t / A_0) \times 100\% \quad (1)$$

$$\ln(C_t / C_0) = -kt \quad (2)$$

Where C_0 denotes the initial concentration of tetracycline, C_t represents the real-time concentration, A_0 indicates the initial absorbance, A_t is the absorbance at the time of measurement, and K stands for the rate constant.

3. Results and discussion

3.1. XRD analysis

As is shown in **Figure 1**, the XRD pattern of sample BFO-1 matches well with the standard data from JCPDS Card No.86-1518, confirming a rhombohedral perovskite structure belonging to the R3c space group ^[10-11]. All diffraction peaks of BFO-1 correspond to the standard card, with peaks at $2\theta = 22.41^\circ, 31.75^\circ, 32.07^\circ, 38.95^\circ, 39.48^\circ, 45.75^\circ, 51.31^\circ$, and 51.74° corresponding to the (012), (104), (110), (006), (202), (024), (116), and (122) crystal planes, respectively. No secondary or heterogeneous phase diffraction peaks were observed ^[10, 12].

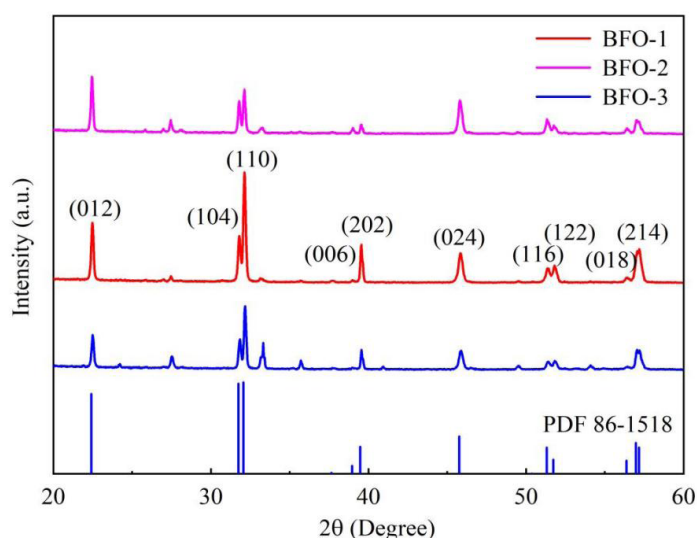


Figure 1. XRD diffraction pattern of pure-phase BiFeO₃ prepared under different conditions compared to the standard card: (a) BFO-1 (b) BFO-2 (c) BFO-3

3.2. SEM analysis

Figures 2(a) and (b) show the hydrothermally synthesized sample BFO-1, which exhibits an average diameter of approximately 50 μm when subjected to a reaction temperature of 180°C. The surface morphology consists of uniformly distributed spherical particles clustered together, revealing lamellar accumulation as depicted in **Figures 2(c) and (d)**. This observation is consistent with previous reports in the literature^[13–14].

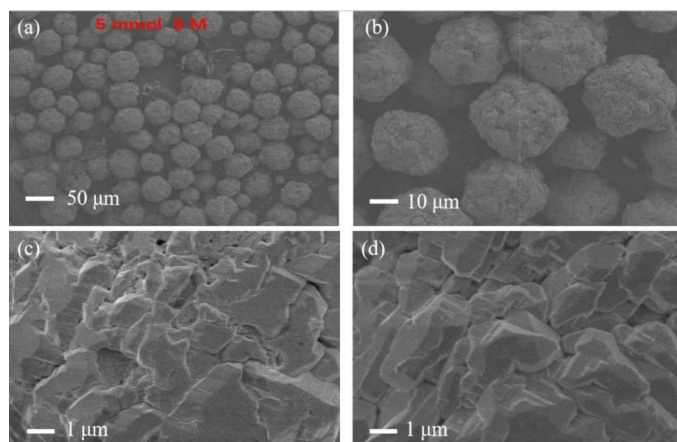


Figure 2. SEM image of BFO-1

3.3. XPS analysis

The XPS spectra in Figure 3(a) reveal the electronic valence states of Bi, Fe, and O in sample BFO-1. In **Figure 3(b)**, two peaks of Bi4f at 163.88 eV and 158.58 eV correspond to Bi4f_{5/2} and Bi4f_{7/2}, respectively. The spin-orbit splitting energy of Bi4f is calculated to be 5.30 eV, which is consistent with well-documented values in the literature for the Bi³⁺ valence state, typically around 5.3 eV, thereby providing strong evidence for the presence of Bi³⁺ in BiFeO₃^[15]. In **Figure 3(c)**, the electron binding energies of Fe2p_{1/2} and Fe2p_{3/2} are observed at 724.14 eV and 710.46 eV, respectively, with a satellite peak at 712.54 eV. The spin-orbit splitting energy of Fe2p is 13.68 eV, indicating the presence of Fe in the Fe³⁺ valence state^[16].

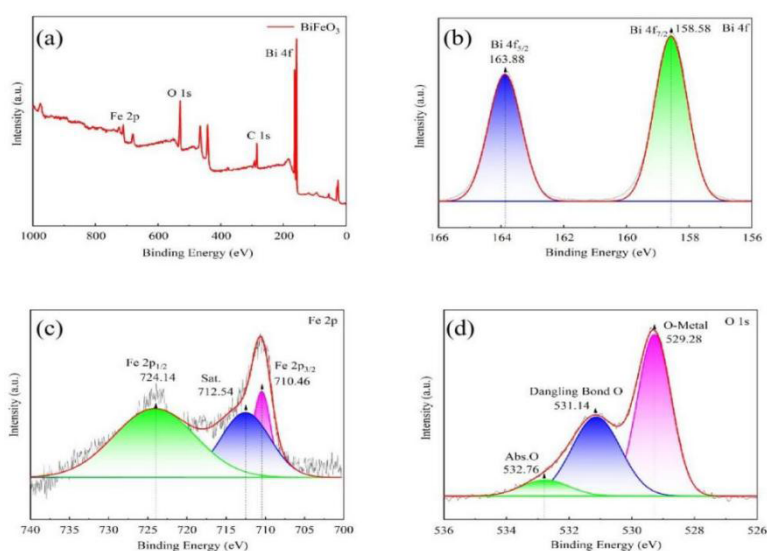


Figure 3. (a) XPS full spectrum of BFO-1 (b) Bi4f (c) Fe2p (d) O1s

Figure 3(d) shows three peaks in the O1s spectrum with electron binding energies at 532.76 eV, 531.14 eV, and 529.28 eV, corresponding to surface-adsorbed oxygen, lattice oxygen, and metal-oxygen bonds, respectively^[17]. The presence of surface-adsorbed oxygen indicates the generation of oxygen vacancies, which favor the adsorption of tetracycline molecules. This not only reduces the electron-hole pair recombination rate but also facilitates the separation and transfer of photogenerated carriers, thereby enhancing photocatalytic and quantum efficiencies^[18].

3.4. Evaluation of photocatalytic degradation performance of tetracycline

Figure 4(a) presents the absorption spectra of the tested tetracycline (TC) solutions, monitored using the UV-2450 spectrophotometer to assess photocatalytic degradation. Notably, the maximum absorbance corresponding to the 357 nm wavelength of the TC decreases during the photocatalytic process. Typically, tetracyclines exhibit strong absorption in the ultraviolet-visible (UV-Vis) range, particularly around 275–280 nm, which is associated with the benzene ring structure, and 350–360 nm, linked to the naphthalene ring and conjugated double bonds. During photocatalytic degradation, these absorption peaks diminish as tetracyclines are broken down into smaller, non-absorbing compounds. This decline indicates a steady reduction in tetracycline concentration, suggesting that active species such as hydroxyl radicals ($\bullet\text{OH}$) and holes (h^+) played a crucial role in effectively degrading the tetracycline solution. The degradation rate was calculated to be approximately 27% after 120 minutes of photocatalysis, using **Equations 1 and 2** as shown in **Figure 4(b)**.

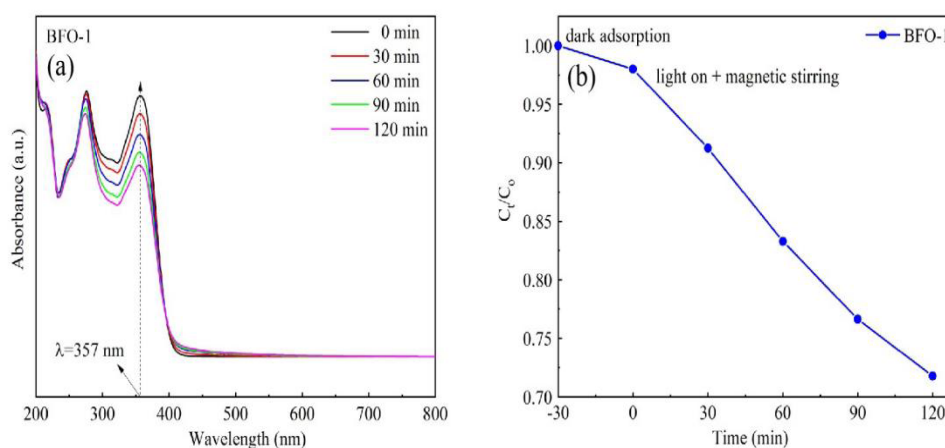


Figure 4. (a) BFO-1 degradation of tetracycline solution (b) BFO-1 degradation rate

3.5. Proposed mechanism of photocatalysis

Figure 5(a) shows the UV-VIS-DRS spectrum of the BFO-1 sample, which exhibits a broad absorption range within the visible wavelength spectrum, with the largest visible wave absorption edge at 530 nm. This expanded absorption spectrum suggests that BFO-1 can effectively absorb and respond to various wavelengths, indicating a robust photon absorption capability. This makes it more readily excited by light, resulting in the generation of a significant number of photogenerated electron-hole pairs, which could enhance its photocatalytic degradation efficiency^[19–20]. The bandgap of the semiconductor material can be estimated using the equation $(\alpha h\nu)^n = A(h\nu - E_g)$, where α represents the absorption coefficient, h signifies Planck's constant, ν denotes the frequency of the absorbed photons, E_g refers to the bandgap value of the semiconductor, A is a constant, and n is a coefficient that

correlates with the semiconductor's characteristics (2 for direct bandgap semiconductors and 1/2 for indirect ones). Therefore, according to Figure 5(b), the bandgap value (E_g) of the BFO-1 sample is determined at about 2.34 eV.

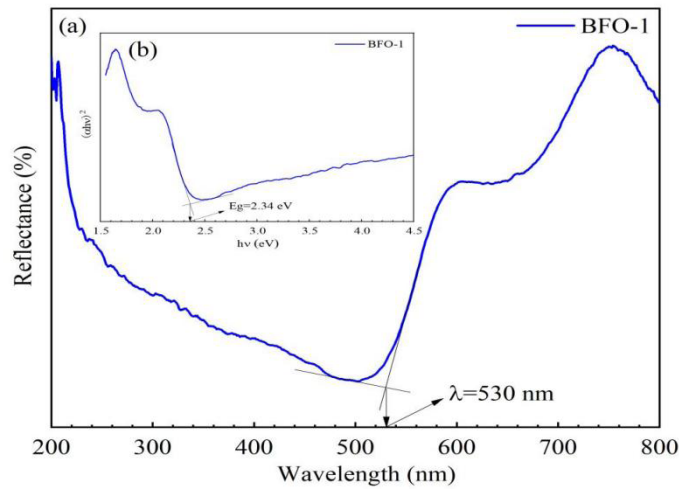


Figure 5. (a) UV-VIS-DRS plot of BFO-1 (b) Bandgap diagram of Tauc curve of BFO-1

X is the absolute electronegativity of BiFeO_3 semiconductors is about 5.89 eV, and E_e is the free electron energy of 4.5 eV on the atomic scale of H. According to Equations 3 and 4, $E_{VB} = 2.56$ eV, $E_{CB} = 0.22$ eV ^[21].

$$E_{VB} = X - E_e + 0.5E_g \quad (3)$$

$$E_{CB} = E_{VB} - E_g \quad (4)$$

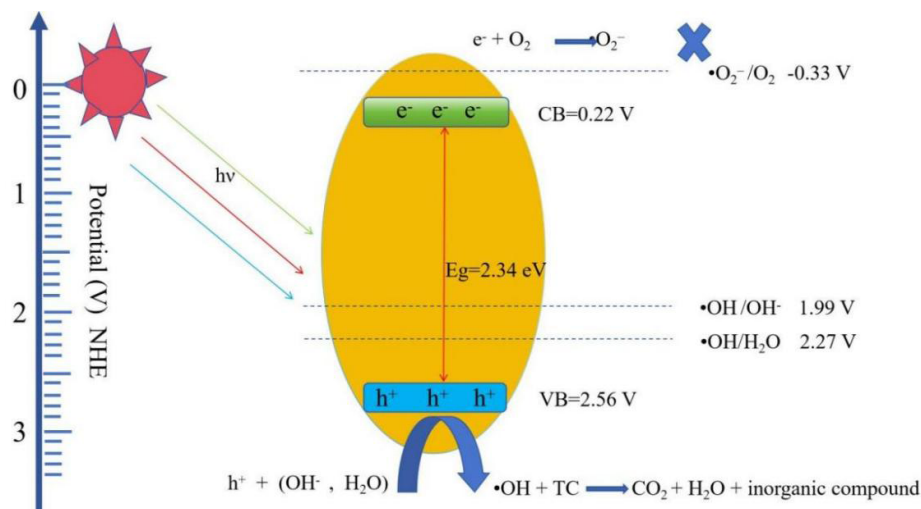
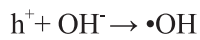
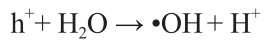
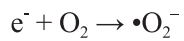
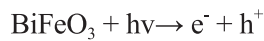


Figure 6. Energy band structure and photocatalytic mechanism of BFO-1

4. Conclusion

In this study, pure-phase BiFeO₃ was successfully synthesized using a simple hydrothermal method at 180°C. The synthesized material exhibited an agglomerated spherical morphology. The UV-VIS-DRS spectrum revealed that the energy bandgap of the synthesized BFO-1 was approximately 2.34 eV. Photocatalytic degradation experiments demonstrated that BFO-1 achieved a degradation efficiency of around 27% for tetracycline (TC) after 120 minutes. The primary active species responsible for TC degradation were •OH radicals, with h⁺ playing a synergistic role.

Disclosure statement

The author declares no conflict of interest.

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Situational Teaching of College English from the Perspective of Constructivism

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Abstract: From the perspective of constructivism, the concept of situational teaching of College English has changed significantly. It emphasizes student-centered and guides students to use the accumulated knowledge to actively construct an understanding of English knowledge. Teachers create teaching situations that are consistent with the actual situation by combining online and offline methods, such as simulating workplace exchanges and foreign tourism scenes, to stimulate students' interest and participation in learning. Situational teaching mode can better stimulate students' interest in learning, improve students' autonomous learning ability, students' autonomous exploration, cooperation, and communication in the situation, improve their language useability and communicative ability, help to cultivate their innovative thinking, and create a good atmosphere for better mastering college English knowledge and skills.

Keywords: Constructivism perspective; University; English; Situational teaching

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1. Introduction

The theory of Constructivism mainly emphasizes the initiative of knowledge acceptance, which is obtained using meaning construction under the guidance of teachers in corresponding situations. As a language discipline, college English situational creation is very important. Appropriate situations can stimulate students' interest and enable them to actively participate in learning, such as simulated workplace interviews, English short play performances, and other situations, so that students have the opportunity to use knowledge in real interaction. This study will elaborate on how to build multiple English situations based on constructivism, analyze the role of improving students' language ability and thinking quality, and strive to open up a new path to improve the quality of college English teaching, help students' English comprehensive quality development, and add bricks to the reform of English teaching.

2. The internal relationship between constructivism theory and college English situational teaching

In the era of rapid globalization, college English teaching is facing the urgent task of cultivating students' comprehensive language ability. Constructivism theory provides a new perspective for this challenge, which is closely connected with situational teaching of college English and reshapes the new model of English teaching.

Constructivism theory emphasizes that learners actively construct a knowledge system, rather than passively accept information^[1]. Based on Piaget's cognitive development theory and Vygotsky's social and cultural theory, it believes that knowledge is gradually formed through interaction and cooperation with others in specific situations based on individual experience. Learners bring their existing knowledge "schema" into the learning environment, and the new information and old schema collide and fuse with each other, contributing to the internalization and updating of knowledge.

Situational teaching of college English is just the fertile soil for the implementation of Constructivism^[2]. In college English classes, the situations created by teachers provide students with real or simulated language use scenarios, such as business negotiations, academic discussions, daily social gatherings, and other situational simulations. These situations activate the students' life experience and language reserve in their minds and make the abstract grammar and vocabulary knowledge have attachment points. Taking business English teaching as an example, teachers show business negotiation situations and introduce common vocabulary in the workplace through multimedia. Students feel as if they are in it. Practical English expressions such as business collaboration and negotiation are no longer just words on paper, but naturally "emerge" due to the needs of the situation, and language knowledge is smoothly embedded into students' existing cognitive structure driven by the situation.

The internal relationship between the two is also deeply reflected in the reshaping of the roles of teachers and students^[3]. Under Constructivism, teachers change from knowledge indoctrinators to guides and promoters. In college English situational teaching, teachers carefully design the situational framework to guide students to explore language rules. For example, in the creation of an English drama performance situation, teachers help students understand the script background and role emotion, and students independently assign roles and guess lines. During this period, teachers constantly make mistakes and correct them. Teachers only inspire students at the key points, so that students can feel the charm of language like native speakers of English, and independently build language application ability.

The social interaction dimension is the manifestation of the close relationship between the two. Constructivism attaches importance to the role of the learning community in knowledge construction. Situational teaching of college English is often carried out in the form of group cooperation. In the task of cross-cultural communication situation, the students discuss the differences of etiquette in different cultures in groups, simulate communication scenes, share their views with each other, correct language errors, broaden the language vision, deepen the understanding of English cultural connotation, and cooperate to complete knowledge construction in the process of multiple thinking collision and frequent verbal communication.

From the perspective of constructivism, situational teaching of college English is the key to opening the door to efficient English teaching. It breaks the traditional dull classroom, makes the knowledge fresh and active, makes English learning a knowledge construction journey for students' exploration, creation, and growth, paves a solid path for cultivating interdisciplinary talents to meet the needs of international exchanges, and promotes college English teaching to a new height.

3. The far-reaching significance of constructivism theory in enabling college English situational teaching

In the wave of college English education reform, constructivism theory is like a lamp, illuminating the way forward of situational teaching and injecting vitality into it. The integration of the two is of great significance.

From the perspective of stimulating learning motivation, constructivism has broken the limitations of traditional college English teaching and changed the old indoctrination teaching method ^[4]. Traditionally, teachers teach, students listen passively, and knowledge is difficult to retain. Nowadays, situational teaching based on Constructivism introduces fresh scenes into the classroom, such as the simulation of the United Nations Conference situation. Students feel the transformation between different identities through role-play, and debate and negotiate for their own “national” interests. This immersive feeling awakened the students’ enthusiasm for participation. English is no longer a cold character in books, but a powerful tool to solve “international disputes” and show diplomatic style. The strong role substitution prompted them to actively participate in language learning, explore expression skills to accurately convey their views, and greatly released their internal drive for learning ^[5].

From the perspective of knowledge internalization, constructivism emphasizes the individual construction of knowledge. In college English situational teaching, students will interpret information according to their own experience when they are in a situation. Taking the situation of English film appreciation as an example, students with different growth backgrounds and film-watching experiences have different understandings of the same film. When discussing the emotions of the characters and the moral of the story, they call the reserved vocabulary and grammar knowledge to explain their views, and the new language expressions are constantly colliding and integrating with the old knowledge. Like metaphors and idioms in the film, students can analyze and understand them in combination with pictures and plots, which is not only better than the boring classroom teaching effect but also can stimulate students to generate new inspiration in the group discussion and in-depth interpretation of the learning connotation of different situations. In this way, language knowledge is deeply rooted in the cognitive system and transformed into the ability to be flexibly used.

Focusing on the cultivation of intercultural communicative competence, constructivism attaches importance to learning community and social interaction ^[6]. The college English classroom is constructed with multicultural situations, such as the simulation activities of the International Cultural Festival. Students are grouped to prepare booths in different countries to introduce cultural characteristics and folk customs. During this period, the group exchanges collided with thinking sparks, understood the cultural taboos and social etiquette differences of different countries, and learned to properly express respect and tolerance in English communication. Members correct language errors, optimize expression, and gradually improve cross-cultural communication literacy from simple greetings to in-depth cultural discussions to meet the needs of global communication.

From the perspective of teacher development, this integration promotes the transformation of teachers’ roles ^[7]. In traditional teaching, teachers are the “authority” of knowledge. Now in constructivism-oriented situational teaching, teachers incarnate as guides and designers. When designing situational tasks, it is necessary to dig deep into textbooks, integrate resources, and consider the differences in students’ cognitive levels; Pay close attention to students’ interaction in the classroom, timely inspiration, and precise instruction, such as organizing English drama rehearsals. Teachers guide students to grasp the characters and the background of the times and help them shape their characters. This process not only improves the creativity of teachers’ curriculum design, but also tempers the ability of classroom control and guidance, and promotes teachers’ professional growth.

4. Analysis of the current situation of college English situational teaching from the perspective of Constructivism

In recent years, the practice of situational teaching of college English under the guidance of constructivism has become increasingly extensive and has achieved initial results, but it also exposes some problems to be solved ^[8].

On the positive side, more and more college teachers recognize the concept of constructivism and try to integrate it into situational teaching. In the classroom, multimedia resources are fully utilized, and video and audio create a colorful English atmosphere. For example, in the oral class, the teacher plays clips of popular American dramas and asks the students to imitate the role dialogue after the pause, so that the students can be exposed to the authentic language situation and the oral expression is more natural and fluent. At the same time, the number of role plays, group discussions, and other activities has increased. Students are grouped to simulate business negotiations and international academic exchanges, build language knowledge in interaction and cooperation, and improve their team cooperation and communication skills. In addition, some schools have also set up virtual situation platforms to enable students to communicate with foreign partners through the Internet, broaden their international vision, and truly feel the cross-cultural communication situation.

However, there are also many practical difficulties. On the one hand, the authenticity of situation creation is still lacking. The situation designed by some teachers is too idealistic and simple, which is divorced from the needs of real life and the workplace ^[9]. For example, in workplace English teaching, the simulated interview scene does not keep pace with the times, the questions are old and the process is formalized, which cannot let students experience the competitive pressure and strain requirements of the real workplace, making it difficult to apply what they have learned. On the other hand, teachers' guidance ability is uneven. Some teachers lack control over students' independent exploration and group cooperation. Group discussions tend to be biased and become small talk, which makes it difficult for teachers to guide them back to the focus in time. Some teachers cannot accurately inspire students when they encounter difficulties in knowledge construction, which weakens students' enthusiasm ^[10].

5. Analysis of college English situational teaching path from the perspective of Constructivism

The core of constructivism theory is that learners actively construct knowledge. It breaks the traditional one-way knowledge transmission mode and regards learning as a dynamic process in which individuals continuously construct cognition in interactive situations by existing experience ^[11].

In terms of situational teaching in college English, the primary strategy is to accurately create situations. Make use of modern educational technology, such as virtual reality (VR) and augmented reality (AR), to create an immersive English learning space for students. Taking tourism English teaching as an example, with the help of VR technology, students feel as if they are in a hot spot in a foreign country, facing street signs, communicating with local people to ask for directions, and buying souvenirs. In realistic situations, they are familiar with common tourism English vocabulary, to improve students' oral communication ability and knowledge reserve. At the same time, introduce current events and cultural trends to create situations. When telling English news reporting skills, select global real-time hot news such as international sports events and major scientific and technological breakthroughs, and let students simulate reporters to report and interview, to master the professional vocabulary and sentence structure of news English in fresh situations ^[12].

Stimulating students' spirit of independent exploration is the key to promoting. In college English situational teaching, the role of teachers has changed from the former leader to the leader. Open questions are designed to

guide students' in-depth thinking. In the context of studying English literary works, teachers raised questions such as "How do metaphors in works reflect social reality" and "The Enlightenment of the growth path of the protagonists to contemporary youth", which prompted students to study the text, consult materials, and explore the deep meaning of the works, rather than passively accept the existing interpretation^[13]. Students are encouraged to independently create English content, such as writing a collection of campus stories and making short English videos. From the creative idea to the presentation of the finished product, English is used throughout the whole process to stimulate creative potential and deepen language understanding and application.

Strengthen the construction of a cooperative learning mechanism. In the process of teaching, teachers can form a multi-ability group to ensure that the members complement each other. In the simulation of English business projects, students who are good at oral communication, copywriting, and data analysis are included to jointly complete market research, business plan writing, and project reporting. Regularly organize group discussions. For the difficulties in English translation, each group discusses the translation strategies of different sentence patterns and vocabulary, shares cultural background knowledge, solves problems with collective wisdom, and promotes knowledge sharing and construction. Build an online and offline hybrid cooperation platform, use the learning management system online to carry out data sharing and group discussion, and organize face-to-face communication and display activities offline to expand the time and space of cooperation. Teachers' guidance and collaboration skills are essential. At the initial stage, students are trained to listen, respect others' views, take turns to speak, and avoid discourse monopoly. Set up group "observers" to regularly feedback on cooperation issues, such as discussion deviation from the theme and uneven participation of members, to promote the group to continuously optimize the interaction mode and improve the cooperation efficiency.

Pay attention to dynamic feedback in the learning process. Teachers continuously observe students' performance in situational learning and give timely affirmation and suggestions. When students' body language is vivid but their English pronunciation is wrong in the context of English drama performance, the teacher first affirms the enthusiasm and expressiveness of the performance, and then provides precise guidance for pronunciation, to strengthen students' self-confidence and guide continuous improvement. At the same time, students are encouraged to make self-evaluations and mutual evaluations. After the group English writing task, members review each other, score, and make suggestions from the aspects of grammatical accuracy, content logic, language style, and so on, and examine the works from multiple perspectives to broaden their knowledge^[14].

In the situational teaching of college English, problem guidance is very important. Problem design should start from the reality of life. For example, with the theme of "campus environmental protection", questions such as "How to introduce the campus waste classification measures to international friends in English" and "What are the English points of writing the campus environmental protection proposal" are thrown out, which are not only related to students' daily life, but also need the use of English knowledge to drive students to actively consult information and organize language. Layer by layer progressive problem chain to guide in-depth thinking. When analyzing English scientific and technological literature, first ask the "main idea of the literature", then go deep into the "core research methods and steps", and finally discuss the "impact of research on the future of the industry." Students gradually explore the problems, build a systematic knowledge framework, and improve their reading comprehension, logical thinking, and English academic writing ability^[15].

When constructing situations, teachers should have a clear positioning of their own identity. Teachers are guides, designers, and good teachers and friends on students' learning paths. Teachers should investigate students' interests and professional needs based on the specific reality and learning situation of students in this class,

integrate resources, and create appropriate situations, such as customizing the “tour guide English actual situation” for the tourism management major, covering the equivalent modules of scenic spot explanation and tourist emergency response, to meet the demands of career development. In the process of learning, teachers incarnate as “scaffolding.” When students encounter complex English grammar problems and cross-cultural communication barriers, teachers timely intervene to provide knowledge clues and strategic suggestions to help students break through the bottleneck, and gradually retire when students can solve problems independently to cultivate their independent learning ability.

6. Conclusion

As an important language subject, college English is the necessary language knowledge ability for students to enter society and the workplace. Only by constantly consolidating the foundation of the English language and broadening the scope of English knowledge, can it stand firm in future development. From the perspective of constructivism, college English situational teaching shows its unique charm. This teaching theory breaks the limitations of traditional English teaching, and through the creation of practical situations, it can better stimulate students’ interest in learning, and students change from passive recipients of knowledge to active constructors. Therefore, educational researchers should explore deeply to help this model shine more brightly in college English teaching and promote the development of teaching to a new height.

Disclosure statement

The author declares no conflict of interest.

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The Heritage Crisis of Traditional Chinese Medicine Exercise Therapy from the Perspective of Cultural Identity

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Abstract: *Research objectives:* China attaches great importance to carrying forward, developing, and innovating the excellent traditional Chinese culture. This is to inherit and carry forward the excellent traditional Chinese culture that is important. Traditional Chinese medicine exercise therapy is an important part of traditional Chinese medicine that should also be preserved. However, under the diversified impact of modern society, its cultural identity is lacking and the inheritance predicament is difficult. Therefore, this paper explores the inheritance crisis of traditional Chinese sports therapy from the perspective of cultural identity. *Research methods:* Literature, interviews, and logical analysis are performed. *Results and analysis:* There are some problems in the process of inheriting traditional exercise therapy, such as a fuzzy sense of identity, anxiety about inheriting identity, and over-commercialization. *Suggestion:* The inheritance of TCM traditional exercise therapy needs the concerted efforts of all sectors of society, strengthening the construction of teaching staff, coordinating the relationship between inheritance and modern education, multi-directional, multi-angle, and multi-level publicity, and telling the story of TCM traditional exercise therapy well.

Keywords: Traditional exercise therapy of Chinese medicine; Cultural identity; Inheritance

Online publication: January 23, 2025

1. Introduction

Traditional Chinese medicine culture is the quintessence of China and a unique national cultural heritage. As an integral part of the Chinese traditional culture, TCM traditional sports therapy includes the subtlety of the Five Poultry plays, the mystery of Taijiquan, the elegance of eight sections of brocade, the Yi Jin Jing, and the Six Character Formula. They carry the traditional Chinese culture and the principle of life and integrate the essence of TCM theory into one move and one style. They are the unique and tenacious cultural gene marks in the inheritance

of Chinese civilization that protect the health and well-being of the nation from generation to generation.

In the contemporary social landscape of accelerated globalization, the breadth and depth of cross-cultural exchanges have reached an unprecedented level. The young generation has grown up in the Internet era of information explosion and multi-cultural symbiosis. Under the intensive impact of Western pop culture and emerging life trends, local culture has been eroded, and the young generation lacks immersive exploration and understanding of the profound cultural heritage and subtle philosophical implications of traditional Chinese sports therapy, let alone cultural identity ^[2]. In such a complex and diverse cultural ecological field, traditional Chinese sports therapy, which is deeply rooted in the thick soil of Chinese civilization and embodies the wisdom crystallization of the Chinese nation for thousands of years, is facing severe challenges.

From multiple dimensions such as deep cognition of cultural identity, social and cultural ecological changes, and educational inheritance mechanism innovation, it has become an urgent and duty-bound core task for the academic community to explore the root causes of traditional Chinese sports therapy inheritance difficulties in an all-round and three-dimensional manner, enhance the public's sense of identity of traditional Chinese medicine culture, and systematically plan the path strategy of breaking the situation.

2. Development status of traditional exercise therapy in Chinese medicine from the perspective of cultural identity

2.1. The displacement of value orientation leads to the ambiguity of identity

The fast pace, high efficiency, and intelligent lifestyle pursued by modern society have significantly changed people's value orientation. In the prevailing environment of efficiency, utilitarianism, and pragmatism, people are more inclined to pursue immediate and definite results. The fast pace and high pressure of modern lifestyle make people more inclined to choose convenient and efficient exercise methods ^[4]. Traditional Chinese sports therapy focuses on inner cultivation, physical and mental harmony, and long-term subtle health improvement. This relatively "recessive" value, which requires deep experience and patient persistence, is difficult to quantify and perceive in a short period, resulting in its marginalization in the modern value system, and people's psychological identity with its cultural value is gradually blurred.

2.2. Identity anxiety and loss reduce people's willingness to inherit

In the process of globalization, multiple cultures collide and blend with each other. Western culture and its sports model have come in large numbers. With its strong visual impact, standardized rules, and extensive commercial promotion, it has attracted the attention of many people, especially teenagers. On the other hand, there is a gap in the connection between inheritance and innovation in local culture. Traditional Chinese sports therapy, as the essence of local culture, failed to fully demonstrate its unique charm and adaptability when competing with foreign cultures ^[5]. In the face of many cultural choices, people have choice anxiety and identity anxiety, and they do not know how to position their relationship with traditional Chinese sports therapy, and then they appear wavering or even lost in cultural identity, which weakens the will to inherit traditional Chinese sports therapy ^[6]. Marathons and basketball games are held in many places, and the number of participants is increasing year by year. However, few people participate in traditional Chinese sports therapy competitions. In the sports goods market, western brands of sports equipment occupy most of the market share, while the sales of traditional Chinese sports equipment such as Taiji sword and Tai chi fan are very limited, which also makes traditional Chinese sports therapy marginalized.

2.3. Cultural imbalance and inheritance fault in education system

Education plays a key role in cultural inheritance, but the current education system has obvious deficiencies in traditional cultural education. Physical education in schools focuses on western modern sports items, and the teaching content of traditional Chinese sports therapy is insufficient, the class time is short, and the teaching method is single, often staying at the level of movement imitation, and the lack of in-depth interpretation of the deep cultural heritage, philosophical thoughts, and health wisdom behind it ^[7]. As a result, the young generation has no opportunity to systematically understand and contact the cultural connotation of traditional Chinese sports therapy in the process of growing up, and it is difficult to establish emotional resonance and identity, resulting in the break of the inheritance chain, the gradual loss of cultural identity in the intergenerational transmission, and the low awareness of students to traditional Chinese sports therapy. According to the survey by Wang Jialian and others, the cognition level of college students of traditional Chinese medicine sports therapy is at a low level (low 34.5%, average 33.8%, high 31.8%) ^[8].

Teachers' teaching level is also the reason that affects students' low cognition level of traditional Chinese medicine exercise therapy. The teaching task of TCM traditional sports therapy is mainly focused on PE teachers, and most of the PE teachers in schools are more specialized in modern sports events and lack traditional Chinese cultural background, which makes PE teachers stay in the shallow teaching of action demonstration and imitation when teaching TCM traditional sports therapy ^[9]. It is difficult for them to deeply explain the TCM theories and philosophical thoughts behind these sports. As a result, students' understanding of TCM traditional sports therapy is limited to body movements, unable to comprehend its unique essence of health and fitness as well as its profound cultural heritage. In terms of teaching methods, due to the lack of accurate grasp of the cultural connotation of traditional Chinese sports therapy, PE teachers may not be able to carry out personalized and systematic teaching designs according to the physical and mental characteristics of students and the principles of traditional Chinese medicine, and it is difficult to give professional and vivid guidance to the key elements such as "meaning", "qi" and "spirit" in the process of exercise. As a result, students cannot truly appreciate the state of physical and mental integration required by traditional Chinese sports therapy during practice, which affects students' interest in learning and the cultural identity of this traditional treasure, and also hinders the effective inheritance and development of traditional Chinese sports therapy in school education to a certain extent.

2.4. The popularity of electronic equipment reduces the proportion of time spent on traditional Chinese sports therapy

The popularization of electronic devices and the diversification of entertainment methods also make people's spare time more occupied by mobile phones, computers, and other electronic devices, reducing the time and opportunity to participate in physical exercise. According to the relevant survey, 50% of China's teenagers use electronic equipment for more than 6 hours a day on average and take part in physical exercise for less than 1 hour. Another survey showed that more than 60 percent of adults participate in physical exercise less than three times a week, and fewer people choose traditional exercise therapy of Chinese medicine.

2.5. Over-commercialization harms the image

Some training institutions in the market under the banner of traditional Chinese sports therapy charge high fees, but the quality of teaching is uneven. Even for the pursuit of economic interests, TCM traditional exercise therapy is over-commercialized packaging, exaggerating its therapeutic effect, misleading consumers, and damaging the

reputation of TCM traditional exercise therapy^[11]. The teaching uses rapid teaching methods, only paying attention to the imitation of the movement, while ignoring the inner spirit and cultural inheritance. This utilitarian teaching method cannot reflect the essence of traditional Chinese sports therapy and is not conducive to its inheritance and development.

2.6. Psychological barrier to social communication and promotion

In the age of information communication, the publicity and promotion of traditional Chinese sports therapy fails to fully consider the psychological needs and cognitive characteristics of the audience. Traditional promotion methods mainly focus on the teaching of technical movements, the language description is difficult to understand, lacks interest and resonance, and it is difficult to attract the attention of the public, especially the young group. In addition, the depth and breadth of mass media reports are not enough, and they fail to create an atmosphere of public opinion conducive to cultural identity. This psychological gap between communication and audience makes traditional Chinese sports therapy unable to penetrate deep into the hearts of the people, and it is difficult to inspire extensive cultural identity and participation enthusiasm at the social-psychological level, which aggravates its inheritance crisis and lack of identity.

3. Suggestions for promoting the cultural identity and inheritance of traditional Chinese sports therapy

3.1. Strengthen cultural publicity, improve cultural identity, and cultivate the national sense of cultural inheritance mission

From the perspective of cultural identity, the institution should strengthen cultural publicity and improve cultural identity. The government can use various media channels, such as TV, newspapers, short videos, public accounts, etc., to publicize the cultural connotation, historical origin, and fitness value of traditional Chinese medicine and sports therapy, and improve the public's awareness and understanding of traditional Chinese medicine sports therapy. Hold a variety of cultural activities, such as traditional Chinese sports therapy competitions, exhibitions, science popularization, lectures, etc., so that the public can personally feel the charm of traditional Chinese sports therapy and enhance cultural identity^[12]. TCM traditional exercise therapy should be incorporated into the physical education curriculum of primary and secondary schools and the curriculum system of colleges and universities. In particular, TCM colleges and universities should make TCM traditional exercise therapy a compulsory course to cultivate students' interest in TCM traditional exercise therapy and their sense of mission in inheriting TCM traditional exercise therapy.

3.2. Expansion of international communication

With the promotion of the "Belt and Road" initiative, traditional Chinese exercise therapy will go to the world and gain more cultural recognition. The unique charm of TCM traditional exercise therapy can be shown to the world through international academic exchanges, cultural exhibitions, and training courses. For example, training courses on traditional exercise therapy of Chinese medicine may be held overseas to attract foreign friends to learn and experience. Network anchors and experts in traditional Chinese sports therapy will be trained to spread and demonstrate traditional Chinese sports therapy at home and abroad. China will cooperate with international sports organizations and medical institutions to promote the international development of traditional Chinese sports therapy.

3.3. Internet + information construction, online and offline coordinated development to meet modern needs

On the one hand, combined with modern information technology, the development of traditional Chinese medicine exercise therapy digital resources, such as video tutorials, mobile phone applications, online courses, digital textbooks, digital books, virtual teaching, and other types of teaching and learning resources, to facilitate the public to learn and practice. At the same time, improve the digital public service platform and pay attention to network connectivity, to avoid the formation of information islands. Traditional Chinese sports therapy organizations and fitness sites should be established offline, and traditional Chinese sports therapy should be promoted in colleges, universities, communities, villages, and towns. Through innovative sports forms, traditional Chinese sports therapy is combined with modern sports events, such as Tai Chi yoga and Baduanjin fitness exercises, to make them more interesting and attractive and increase the participation of the public ^[13]. On the other hand, educators can use the short video platform to make exquisite short videos, tell the story of traditional Chinese sports therapy, invite Chinese medicine experts and sports experts to appear together, and use plain language to break down the moves and forms of Taijiquan, Baduanjin and other sports, and explain the operation principles of meridian, qi and blood in detail; Create interesting animation science popularization, transform ancient TCM theories into vivid animated characters and plots, so that children can understand the mysteries of traditional sports in joy. Live interaction is used to answer the audience's questions in the practice process in real time so that the public can feel that traditional Chinese sports therapy is not a remote "spring snow", but a practical and effective health "magic" close to daily life, to narrow the distance with the public, enhance its cultural affinity, and attract more people to join the ranks of inheriting and promoting traditional Chinese sports therapy.

3.4. Strengthen the construction of teaching staff and train professional talents

The government should increase the investment in the education of traditional Chinese medicine exercise therapy, strengthen the construction of teachers, and improve the teaching quality. In the recruitment of physical education teachers, the assessment of traditional Chinese medicine literacy should be increased ^[14]. A sound personnel training system should be established to train traditional Chinese medicine exercise therapy instructors and coaches adapted to different levels of education through vocational training. Physical education teachers in schools are mainly responsible for the teaching and popularization of traditional Chinese medicine exercise therapy in residential areas, villages, towns, and streets, and teachers of relevant majors in traditional Chinese medicine colleges are responsible for popular science. To meet the needs of different types of people in traditional Chinese medicine sports therapy.

3.5. Strengthen market supervision and standardize the development of the industry

Supervision of traditional exercise therapy training institutions and merchants should be strengthened to regulate market behavior and crack down on false publicity and fraud. It will guide training institutions and merchants to establish correct business concepts, pay attention to the inheritance of cultural connotations and traditional values, and promote the healthy development of the industry ^[15]. To formulate industry standards, standardize the teaching content, teaching methods, and assessment standards of traditional Chinese medicine exercise therapy, and improve the overall level of the industry.

4. Concluding remarks

The heritage crisis of traditional exercise therapy in Chinese medicine at the level of cultural identity cannot be ignored. However, the crisis has a turning point, educators must soberly realize that regaining cultural identity is the key to overcoming the situation. On the one hand, the education system should carry out educational reform, integrate the cultural education of traditional Chinese medicine sports therapy into the curriculum system, and train teachers with sports skills and traditional Chinese medicine cultural literacy, so that the growth of the young generation can be steeped in traditional wisdom and build a solid cultural foundation. On the other hand, with the help of modern media, the story behind traditional Chinese sports therapy should be told in an innovative form, to strengthen domestic and international communication, make it close to life and go to the world. Moreover, educators should strengthen market supervision, standardize the development of the industry, and maintain the image of traditional Chinese sports therapy. All sectors of society also need to make concerted efforts to organize a variety of activities, create an atmosphere for the participation of the whole people, let the public feel its charm in the personal experience, and reshape the cultural identity of traditional Chinese sports therapy. Traditional Chinese sports therapy is the shining pearl of the Chinese nation's thousand-year-old health concept and spiritual pursuit. Only with the concerted efforts of all parties can it shine in the tide of time, transcend the boundaries of time and space, and continue to inject vitality into the health, well-being, and cultural prosperity of mankind.

Disclosure statement

The authors declare no conflict of interest.

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Study on the Effect of Coal Bed Water Injection Wetting Enhancer on the Wettability of Hongliulin Bituminous Coal

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Abstract: A coal seam water injection wettability enhancer was developed through surfactant compounding to enhance water injection and dust suppression in underground coal seams of coal mines. The enhancer, comprising an anionic surfactant (SAS-60) and a nonionic surfactant (APG), was evaluated for its impact on the wettability of Hongliulin bituminous coal using surface tension, contact angle, and Fourier transform infrared spectroscopy tests. The results revealed that the surface tension of the coal seam water injection wetting agent (AS) was 26.51 mN/m with a contact angle of 26.66°. Furthermore, AS demonstrated superior wetting properties by exhibiting optimal peak area and percentage of hydroxyl structures, thereby significantly enhancing the wetting properties of coal dust. These findings offer valuable insights for mitigating coal mine dust and developing effective coal seam water injection wettability enhancers.

Keywords: Coal dust; Wettability; Coal mine dust control

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1. Introduction

In recent years, coal production has gradually shifted to fully mechanized mining, and with the expansion of fully mechanized mining equipment, the amount of dust generated in the coal mining stage has increased significantly, and the concentration of dust has also increased^[1-2]. It poses a serious safety hazard to the safe operation of mines and the physical and mental health of operators and is highly susceptible to the development of occupational pneumoconiosis. Pneumoconiosis remains the most serious occupational disease among coal miners. In the process of coal mining, water injection into coal seams is a sustainable dust control measure that can play a role in wetting the coal seams, thus reducing the amount of coal dust generated during the mining process^[3-4]. Therefore, it is of great significance to adopt effective dust prevention and control technology to improve the safety of coal production and maintain the health of workers.

Chemical dust suppression represents a critical facet of coal mine dust prevention and control technology,

attracting considerable scholarly attention owing to its promising efficacy and broad developmental potential. The capacity of surfactants to modify the interfacial characteristics of coal dust stands as a pivotal factor in dust mitigation, with extensive research focusing on the impacts of anionic, nonionic, and cationic surfactants on microstructure and water injection efficacy. Scholars have delved into theoretical and experimental avenues to elucidate the dynamics of water migration in coal seams to achieve optimal wetting effects. Initial endeavors incorporating surfactants into coal seam water injection processes revealed enhanced injection efficiency. Subsequent investigations explored the influence of surfactants on water injection in coal seams. Wang et al. studied the effects of cationic and anionic surfactants on water injection in long-flame coal seams and found that the adsorption of cations was stronger than that of anions, and the water solubility of cations was better than that of anions^[5]. Wang et al. independently developed a cationic surfactant using an alkane mixture as a lubricant and verified the fracturing effect of surfactant by contact angle experiment. The addition of surfactants is beneficial to water injection and dust suppression in coal seams, but no scholars have studied the effect of compound surfactants as water injection wetting agents in coal seams on the wettability of Hongliulin bituminous coal.

Given this, immersion modification experiments employing anionic and nonionic surfactant solutions were conducted on highly metamorphosed Hongliulin coal specimens. Surface tension tests via the platinum plate method, contact angle assessments using the seated drop method, and infrared spectroscopy analyses were carried out to evaluate alterations in the surface groups of the coal samples. These experiments lay the groundwork for leveraging coal seam water injection wetting enhancers to enhance bituminous coal water injection effectiveness and curtail respiratory dust emissions in coal mining operations.

2. Experiments

2.1. Materials and methods

2.1.1. Collection and preparation of coal samples

The experimental coal samples were taken from the Hongliulin coal mine, and the sampled coal samples were cut and crushed into coal sample particles with a particle size of 200 mesh (0.074 mm) by hand and ball mill. The coal sample particles were placed in a drying oven at 40°C for 24 hours and sealed in a vacuum bag to prepare for the next test. The entire experimental process is presented in **Figure 1**.

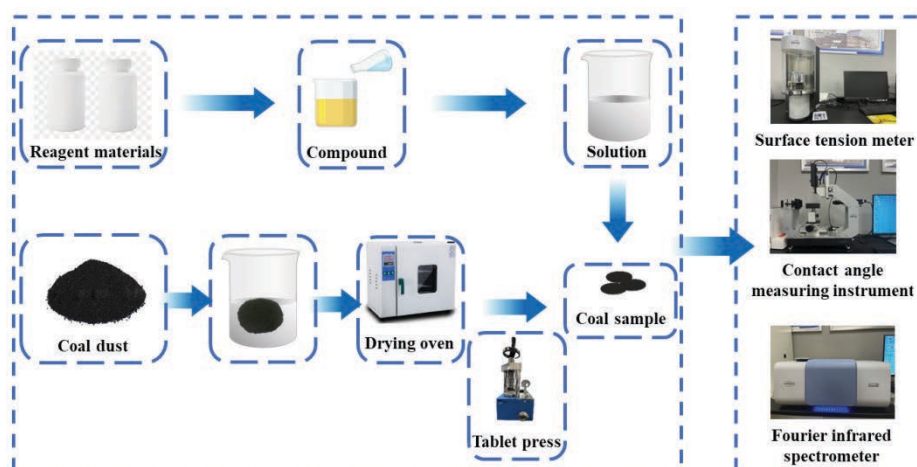


Figure 1. Flow chart of the experiments

2.1.2. Selection of wetting agents for coal seam injection

Previous studies demonstrated that the anionic surfactant SAS-60 and the nonionic surfactant APG exhibit synergistic effects on coal dust wetting and downhole dust control. SAS-60 is an effective anionic surfactant with a penetration force comparable to JFC, offering excellent wetting properties and biodegradability, making it an environmentally friendly option ^[7]. APG, a novel nonionic surfactant, combines the benefits of both nonionic and anionic surfactants, possessing superior compatibility, stability, and surface activity while being fully biodegradable without causing environmental harm. Consequently, SAS-60 and APG were chosen for the coal bed water injection wetting agent due to their economic and ecological advantages.

2.2. Experimental setup

2.2.1. Surface tension

The surface tension of SAS-60, APG, and SAS-60 compounded with APG at different mass concentrations was determined using the platinum plate method on a K100 smart surface tensiometer from KRÜSS, Germany. For the surface tension experiments, the solutions were placed in the sample stage of the smart surface tension meter. Before starting the test, the platinum plates were cleaned and cauterized, and waited for them to cool down before starting the surface tension values. In the surface tension test, three replicate measurements were taken for each solution and the average value was taken as the result.

2.2.2. Contact angle

Before performing the contact angle experiments, 0.20 g of 200 mesh dry coal powder needed to be weighed and pressed into coal flakes under 20 MPa pressure. The contact angle of SAS-60, APG, and SAS-60 composite with APG was measured by using the seated drop method on a DSA30 contact angle measuring instrument from KRÜSS, Germany. Three repetitions were made and the average value was taken to ensure the accuracy of the experiment.

2.2.3. Fourier transform infrared (FTIR)

In this study, an infrared FTIR spectrometer was used with the wave number range set to 4000-400 cm^{-1} , the scanning resolution to 4 cm^{-1} , and the number of scans to 32. Coal samples and KBr were ground in agate mortar at a mass ratio of 1:99, and the resulting transparent sheets were placed in the infrared spectrometer. Each experiment was repeated more than three times to ensure the accuracy of the experiment.

3. Results and analysis

3.1. Surface tension analysis

Surface tension significantly influences the effectiveness of dust suppression measures, with lower values indicating better wettability of coal dust. This study utilized six concentrations (0.01% to 0.2%) to measure the surface tension of 18 groups. Results show that the surface tension decreased notably with increasing APG concentrations, from 55.78 mN/m at 0.01% to 27.73 mN/m at 0.2%, a reduction of 50.29%. In contrast, SAS-60 exhibited a gradual decrease followed by stabilization, dropping from 31.28 mN/m at 0.01% to 27.52 mN/m at 0.2%, a total decrease of 12.02%. When compounded with APG, the surface tension of the coalbed water injection wetting agent AS remained lower than that of SAS-60 above 0.03% concentration, reaching a minimum of 26.61 mN/m at 0.2%. This effect can be attributed to electrostatic repulsion among anionic SAS-60 molecules at the gas-liquid interface, leading to larger intermolecular spacing. APG molecules, possessing numerous oxygen functional

groups, enhance hydrogen bonding with water and diffusivity, effectively filling gaps between SAS-60 molecules and further reducing the surface tension of the resulting wetting agent AS.

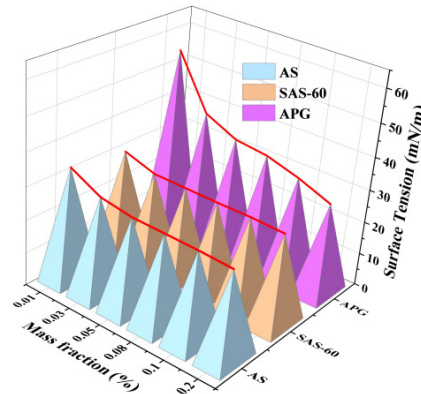


Figure 2. Surface tension of solutions at different concentrations

3.2. Contact angle test analysis

The contact angle is an important index to describe the wettability of coal dust solution [8]. The experimental results for the contact angles of APG, SAS-60, and the AS coal bed water injection wetting agent are presented in **Figure 3(a)**, with trends shown in **Figure 3(b)**. In the APG solution, the contact angle of coal dust gradually decreased as the concentration increased from 0.01% to 0.2%. Minor reductions in contact angle were observed for incremental concentrations of 0.01% to 0.03%, 0.05%, and 0.08%, with decreases of approximately 2.89°, 0.87°, and 3.78°, respectively. However, at higher concentrations of 0.1% and 0.2%, the contact angle sharply declined to 36.39° and 34°. Conversely, the SAS-60 solution showed a gradual decrease in contact angle as the concentration increased from 0.01% to 0.2%, although the reductions were modest. For concentrations from 0.01% to 0.08%, the contact angle decreased by approximately 15.27°, 1.34°, and 1.52%, while reductions at 0.1% and 0.2% were minor, at 4.13° and 0.75°, respectively. The AS wetting agent also exhibited a gradual decrease in contact angle, dropping by about 7.27° from 0.01% to 0.2%. Notably, the AS solution showed a more significant reduction in contact angle at lower concentrations compared to APG and SAS-60. Overall, the contact angle for AS ranged from 33.93° to 26.66°, consistently lower than that of APG and SAS-60. The AS solution demonstrated superior wetting performance at equivalent concentrations, with a gradual reduction in contact angle indicating enhanced wettability with increasing concentration. In contrast, the contact angle trends for APG and SAS-60 were more complex, exhibiting larger variations across different concentrations.

Combining the results of surface tension and contact angle assessments, and considering the cost-effectiveness of utilizing different surfactant concentrations, a 0.2% concentration of APG and SAS-60 in a 1:1 ratio for compounding the AS coal bed water injection wetting agent was chosen for conducting Fourier transform infrared (FTIR) experiments.

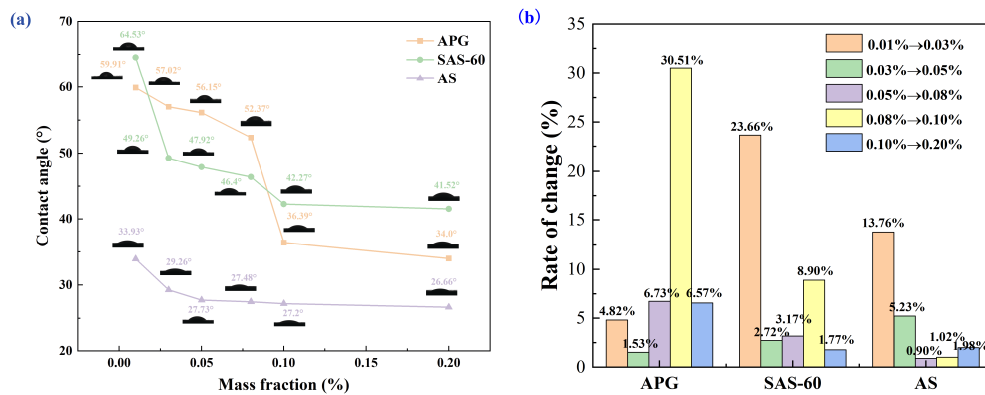


Figure 3. Contact angle of solutions at different concentrations and the trend of contact angle of solutions at different concentrations

3.3. Fourier transform infrared experiment

The infrared data obtained were divided into four regions according to the class of functional groups. 900–700 cm^{-1} denotes aromatic functional groups, 1800–1000 cm^{-1} denotes oxygenated functional groups, 3000–2800 cm^{-1} for aliphatic functional groups, and 3600–3000 cm^{-1} for hydroxyl structures [9]. For absorption peaks in the same wavelength range and under the same test conditions, the change in the number of functional groups can be expressed in terms of peak area and percentage of peak area. Different surfactant solutions did not affect the absorption bands and characteristic absorption peaks, and the functional group structure of the coal samples did not change, but the peak area changed, indicating that the solutions changed the relative content of functional groups. In this paper, the infrared spectra of water and conventional surfactant w=0.2% SDBS as a control group were compared with those of w=0.2% APG and SAS-60 coal bed water injection wetting agent AS treated coal samples as shown in **Figure 4**.

Usually, the hydroxyl structural group is more reflective of the wetting property in terms of wettability [10]. Among the hydroxyl structural groups, the OH... π bond has an important influence on the wetting properties. **Figure 5** demonstrates the peak area (a) and the percentage of functional groups (b) in the absorption region of the hydroxyl structure (3600–3000 cm^{-1}).

According to the fitting results in the figure, the peak areas of OH... π bonds are 9.2478 (water), 10.8218 (SDBS), and 13.8057 (AS), and the percentages of peak areas are 22% (water), 22% (SDBS) and 25% (AS), respectively. Based on the experimental results, it can be concluded that the AS samples showed better results in terms of coal dust wetting properties, followed by the SDBS samples, while the water samples showed relatively low wetting properties.

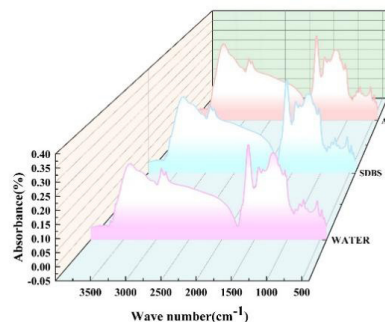


Figure 4. Infrared spectra of different surfactants adsorbed on the coal dust surface

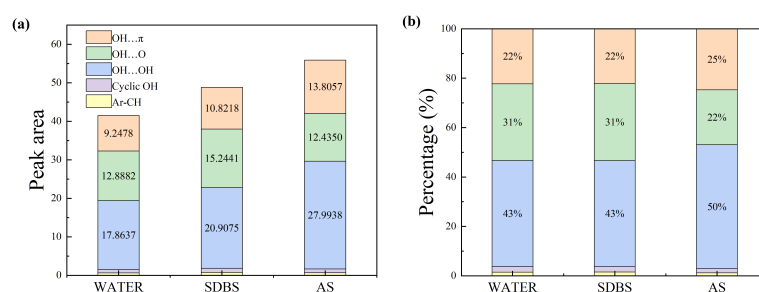


Figure 5. Peak area (a) and percentage of functional groups (b) in the absorption region of the hydroxyl structure (3600–3000 cm⁻¹)

4. Conclusion

This study explored the impact of a coal seam water injection wetting enhancer on the wetting characteristics of Hongliulin bituminous coal, leading to the following conclusions.

The coal bed water injection wetting enhancer AS solution exhibited exceptional wetting properties across various concentrations, characterized by low surface tension values and minimal contact angles.

The coal bed water injection wetting enhancer AS demonstrated superior peak area and percentage concerning hydroxyl structure related to wetting efficacy, thereby markedly enhancing the wetting performance of coal dust. This enhancement can effectively mitigate the adverse effects of coal dust on workers and the environment.

Disclosure statement

The author declares no conflict of interest.

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The System Construction of Moral Artificial Intelligence: From the Perspective of Normative Ethical Theories

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Abstract: With the rapid progress of technology, the decision-making and behaviors of artificial intelligence have begun to shift from external settings to internal development. Intelligent agents gradually possess varying degrees of adaptive, decision-making, and behavioral abilities, and their autonomous capabilities are continuously enhanced. For moral considerations, artificial intelligence with autonomous decision-making and behaviors has begun to be regarded as a moral agent. Therefore, how traditional morality can play an autonomous role in intelligent technologies has become a problem that must be faced. The three main theories of normative ethics, consequentialism, deontology, and virtue ethics all have the potential to solve this problem. This article aims to use normative ethical theories to construct an artificial intelligence system capable of making moral decisions, and it is necessary to ensure that the autonomous reasoning of artificial intelligence can be constrained by human social morality and values, remain consistent with human values, and assume the “responsibility” of decision-making.

Keywords: Moral artificial intelligence; Consequentialism; Deontology; Virtue ethics

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1. Introduction

In the early days of computerization, the cyberneticist Norbert Wiener pointed out that technology can help humans become better people and create a more just society, but to achieve this, humans must control technology^[1]. Among the three major information technology revolutions in history, the latest one is artificial intelligence technology, and this technology will bring many moral (ethical) problems.

Human morality depends on the rule systems such as moral standards, values, and laws and regulations in the context of human social culture, and the “morality” of artificial intelligence is similar. Researchers have pointed out that the moral behavior of artificial intelligence in society is mainly a normative issue rather than a

descriptive one ^[2]. Moral norms can not only shape human moral behavior but also be internalized as the self-restraint of artificial intelligence and serve as the foundation for establishing “morality.” Therefore, verifying whether the intelligent system complies with the existing legal framework is only the first step. More importantly, it is necessary to ensure that it can interpret and apply human moral values, clarify what the morality of artificial intelligence means, and how the system follows morality and adheres to certain value orientations.

2. Ethical basis of moral artificial intelligence

From the perspective of understanding moral principles and applying them to the design of artificial intelligence systems, normative ethics has special applicability. Consequentialism (utilitarianism), deontology (duty ethics), virtue ethics (virtue ethics), and so on, are typical representatives of normative ethics. They not only put forward norms for human moral behavior but also attempt to solve moral dilemmas. Therefore, it is entirely possible to apply normative ethics to the design of artificial intelligence systems by exploring the established human moral system.

2.1. Consequentialism and artificial intelligence

Consequentialism holds that the morality of an action depends on the consequences of the action ^[3]. A morally correct action is an action that produces “good” results. Therefore, whether an action is morally correct can be determined by examining its consequences, which are either caused by the action itself (act utilitarianism) or by the general rules that require such an action (rule utilitarianism).

In the consequentialism model, artificial intelligence must know the consequences of an action and what they mean for itself, humans, and other things, and also be able to evaluate these consequences. For humans, it is difficult to determine all the actual consequences of a certain action, let alone those of a rule. However, usually, an action (or rule) will increase or decrease general utility, which is of great significance for guiding the design of artificial intelligence. Considering various possibilities not yet occurred, the evaluation of consequences by moral artificial intelligence is mainly not for actual consequences but for expected consequences. Therefore, moral artificial intelligence based on consequentialism usually adopts heuristic search algorithms, which consist of search, stop, and decision-making strategies and can continuously develop ^[4]. This is very useful when rapid decision-making is required, but it is also a limitation at the same time.

2.2. Deontology and artificial intelligence

Deontology is a normative moral stance and is unrelated to the character of the actor (compared to virtue ethics). It judges the morality of an action according to rules and does not consider consequences (compared to consequentialism). Humans have the rational ability to create and abide by rules. Rules allow the emergence of duty-based moral norms, which are crucial to human existence. “Duty” is very important in Kantian ethics. Kant believed that responsible actions have moral value. In the deontology model, duty is the starting point and can be transformed into rules, which are divided into rules and meta-rules.

Deontology adheres to the view that moral law is a rational framework for the moral evaluation of the subject’s behavior, so it is considered that it can be more easily formalized to produce “responsible” artificial intelligence ^[5-6]. Its algorithm for rule-based moral judgment is very suitable for the construction of moral artificial intelligence. The application of Kant’s categorical imperative to artificial intelligence is regarded as a “top-down”

construction. This method defines the morality of an action based on a set of predetermined rules, and artificial intelligence can only take a certain action when it is allowed by the established rules. Therefore, the expected behavior can be placed in the traditional deontological categories (prohibited, permitted, and mandatory) by simply conducting a consistency test on the action rules. Here, moral judgment is the result of the consistency test, the test is the method of constructing rules, and moral behavior is to establish a set of rules.

2.3. Virtue ethics and artificial intelligence

Producing acceptable moral behavior in a sufficiently small and predictable system like deontology, or moral reasoning when the problem definition is clear enough and information is complete as in consequentialism, is usually not fully satisfied in real-life scenarios because there is a large amount of incomplete information in real-life scenarios. Virtue ethics is rooted in classical moral philosophy and is very useful in evaluating, judging, and taking actions that are in line with character. Virtue ethics focuses on the internal characteristics of people (such as temperance, justice, courage, and wisdom), and unlike deontology and consequentialism, it is a subject-based view.

Aristotle's teleology provides ideas for artificial intelligence research based on virtue ethics. It not only includes the overall goal orientation based on moral behavior but also pays special attention to value orientation. Therefore, the key to constructing moral artificial intelligence based on virtue ethics lies in making values consistent with humans and selecting goals according to the complex values of humans. There is a high similarity between machine learning and virtue ethics. Goal orientation is a core part of modern artificial intelligence, especially advanced robotics. Therefore, virtue ethics is more suitable for the bottom-up moral learning design method based on machine learning. Aristotle also believed that virtues must be discovered and learned through practice, and machine learning also improves the ability of machines to perform tasks through experience. Therefore, machines cannot possess practical wisdom and implement moral behaviors before learning from real data. If virtues can be well combined with functions and task execution, it is entirely possible to develop artificial intelligence based on virtue ethics.

Artificial intelligence based on virtue ethics also has deficiencies in interpretability. It is difficult to explain or prove how its virtues are formed through experience, and virtues are the basis of its actions. If artificial neural networks are used to realize the ability of artificial intelligence to learn virtues, it will bring greater problems because it is almost impossible to extract intuitively understandable reasons from numerous network weights. Therefore, virtue ethics requires more judgment calls and needs to introduce a new interpretive reasoning mechanism to evaluate probabilities and risks, which may not be very reliable in itself.

In short, the following deontology is the simplest way to achieve moral artificial intelligence. Although it is only the direct application of rules, it requires higher-level rules to reason about the actions themselves. Artificial intelligence must know the logical relationship between its actions and the rules. Consequentialism can be achieved through heuristic search, but when information is limited and the impact of actions cascades in continuous interactions, it is necessary to determine the degree of moral reasoning, ignore irrelevant information, and adopt heuristic algorithms with limited search. Virtue ethics can use machine learning techniques, but it requires a new mechanism to reason about motives and consider the behaviors and results caused by motives, which is a more complex model and needs to use algorithms such as the expected utility function to handle "regret" and create new solutions to dilemmas.

3. Responsibility undertaking of moral artificial intelligence

In human society, whether it conforms to moral norms is usually judged according to how moral agents choose behaviors and their consequences. As expected, the behaviors of moral agents will produce good results morally. However, there is still great uncertainty when artificial intelligence takes action. Sometimes the actions will not achieve the expected results or even make wrong choices. When errors occur or laws are violated, it means a problem of responsibility. Therefore, moral artificial intelligence must be able to provide explanations for its decisions and behaviors. If it cannot explain its moral reasoning, it not only means the opacity of the system but also means that it cannot be responsible.

If artificial intelligence lacks a certain form of responsibility, it will not have autonomous ability. Without an accountability system, interactions will not have transparency. Therefore, the construction of moral artificial intelligence should be based on the principles of accountability, responsibility, and transparency (i.e., ART)^[7].

3.1. Accountability

Accountability is the primary condition for responsible artificial intelligence, which refers to the system's ability to explain and justify its decision-making mechanism. On the one hand, accountability means that the system can explain. Explanation is to base abstract principles (such as fairness or privacy) on specific system functions. John Langshaw Austin believed that the study of explanation can clarify moral norms in many ways. Human society requires artificial intelligence to prove its moral reasoning ability or at least guarantee the scope of decision-making. Explanation can reduce system opacity and support the understanding of system behaviors and limitations. On the other hand, accountability means that the system's decision-making mechanism must be proven from algorithms and data. The value-sensitive design method has been widely used in the fields of engineering and design and has great potential in ensuring accountability.

3.2. Responsibility

When artificial intelligence has control over actions, it needs to bear responsibility^[8]. Consequentialism can play an important role in this regard. However, even if the artificial intelligence system is the direct cause of action, the chain of responsibility must be clear enough, and it is necessary to clarify the relationship between the decision-making behavior of artificial intelligence and stakeholders. For example, when artificial intelligence works as expected, the responsibility lies with the user, which is due to its tool attribute; or when immoral behaviors occur due to errors or accidents, in this case, the designer should bear the responsibility. Although learning and adaptive abilities are the expected features of most artificial intelligence systems, they are ultimately caused by algorithms. Moreover, the consequences of behavior based on learning are usually difficult to fully predict and guarantee, so continuous evaluation is needed, which is the key to the moral learning design method. The responsibility issue of artificial intelligence is very complex and also belongs to a legislative issue.

3.3. Transparency

The explanation of behaviors needs to maintain transparency in the selection and decision-making of algorithms, data sources, and stakeholders. That is to say, it must be possible to review the design and working mode of algorithms. Deontology has outstanding advantages in this regard. The goal of transparency is to provide sufficient information to ensure the safety and controllability of artificial intelligence. If openness can be achieved in all aspects related to the system (i.e., data, design process, algorithms, stakeholders, etc.), transparency in the system

can be guaranteed. The transparency design method is an important method for the design of moral artificial intelligence. The opacity in machine learning, the so-called “black box”, is often regarded as one of the main obstacles to transparency. Therefore, it is necessary to reconsider the algorithm design of machine learning, or even go beyond the deep learning model, innovate in-depth research models, and open up new algorithmic frontiers.

4. “Value” construction of moral artificial intelligence

Human morality is universal values and behavioral norms, and values are the basis for explaining attitudes and behavioral motives. The interaction between technology and humans is fundamentally a value interaction, and the value orientation of technology is the result of human application. Artificial intelligence capable of autonomous decision-making, whether it can self-improve or not, inherently needs a “value library”, which is its code of conduct. Therefore, values are at the core of moral artificial intelligence.

As artificial intelligence has more and more autonomy in decision-making and environmental operations, it must be designed to learn, adapt, and follow the moral norms and values of the target groups. Research shows that values in different cultures are quite consistent^[9]. This indicates that human motives have a similar structure. Of course, even if the types and structures of human motives expressed by values are universal, individuals and groups also have different value “priorities” or “hierarchies.” Differences in the order of consideration lead to differences in decisions and behaviors.

Shalom H. Schwartz’s theory of basic human values is important in the field of cross-cultural research, which clarifies the common characteristics and differences of values^[10]. The core of the theory of basic human values is that values form a circular structure, reflecting the motives expressed by each value. This circular structure encompasses the conflicts and compatibilities among ten universal values recognized by major cultures, and there is a dynamic relationship of conflict and consistency among values. These values constitute four higher-level dimensions: openness, self-enhancement, conservation, and self-transcendence. Values can be slightly or strongly opposed to each other, which causes values to change in a circular structure along two poles.

The structure of the dynamic relationship among values indicates that any behavior that pursues a certain value will conflict with some values but be consistent with others. Schwartz’s value structure model provides ideas for the value setting of artificial intelligence. First, the importance rating of values. The Schwartz Value Survey (SVS) directly measures values and scores and ranks the importance of values. Therefore, weights can be used to evaluate and balance values^[11]. Second, the direct similarity judgment task. The Portrait Values Questionnaire (PVQ) indirectly measures values and scores the similarity of values. Based on the neural basis of human perceptual similarity judgment, computational models can be established, such as the feature representations generated by the Deep Convolutional Neural Network (DCNN). Third, group classification. The value theory can predict class behaviors with consistent value expressions. Fourth, spatial arrangement. Based on Multi Dimensional Scaling (MDS), the value structure model divides the multidimensional space into different regions containing each value item. MDS is a very useful visual technology in artificial intelligence for evaluating things in multiple dimensions^[12].

However, there is still a long way to go for the “value” setting of artificial intelligence for developers, and several problems need to be solved. First, it is necessary to establish a value library for specific groups or individuals affected by artificial intelligence and determine specific norms and attributes. Second, norms have the property of dynamic change, which requires artificial intelligence to have the ability to update and self-improve,

and the process should be transparent^[13]. Third, after being integrated into the artificial intelligence system, the system may have algorithm biases and be affected by conflicts among multiple values. Solving such conflicts requires quantitative weighting among values, so the algorithm also needs to be transparent^[14].

The realization of “moral” artificial intelligence is a complex systematic project. For artificial intelligence to become a “trustworthy” and “responsible” human companion, it must maintain extensive consistency with humans in terms of moral theoretical basis and expected values^[15].

Many moral theories have the potential in this regard. By integrating multiple moral theories, artificial intelligence may generate a better moral system than any individual through machine learning and multi-moral intelligent agents. At present, moral artificial intelligence is still in its infancy and is mostly used in specific fields. It is entirely foreseeable and hopeful that in the future, moral reasoning will be transferred from programmers to intelligent systems for autonomous operation, thereby creating a general moral artificial intelligence with a human-level moral system^[16].

Disclosure statement

The author declares no conflict of interest.

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Innovative Development and Practical Exploration of Digital Technology Empowering the Funding Education Work in Colleges and Universities

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Abstract: In the higher education system, the work of developing funding education is a key link to helping students with financial difficulties grow up and become successful, and it is also an important starting point for implementing the fundamental task of fostering virtue through education. With the rapid development of digital technology, the work of funding education in colleges and universities has ushered in new opportunities but also faces many challenges. Traditional funding strategies and measures can hardly meet the diverse and personalized needs of students, which prompts colleges and universities to comply with the trend of the times, and actively integrate digital and information technology to promote the sustainable development of funding education work. This paper analyzes the current situation and problems of funding education work in colleges and universities, and puts forward a series of innovative initiatives: building a panoramic view of the funding education system and optimizing the management process path; improving the structure of funding education system and enhancing the effectiveness of precise funding; deepening the practical results of funding education and empowering students' diversified growth; strengthening the supervision barrier and safeguarding the fairness and justice of funding education work. The purpose of this research is to provide a reference for the work of funding education in colleges and universities, focus on exploring new paths of funding education, and promote funding education work to move towards a more scientific, efficient, and precise direction, to realize the transformation from protection-oriented funding to development-oriented funding.

Keywords: Digital technology; Higher education; Funding education; Innovative initiatives

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1. Introduction

In the current era when the digital wave is surging vigorously, digital technology is changing every aspect of

our lives and society at an unprecedented speed ^[1]. The report to the 20th National Congress of the Communist Party of China clearly put forward “accelerating the development of the digital economy, further integrating it with the real economy”, and mentioned “digitalization of education” for the first time, which undoubtedly points out the direction for the transformation and development in the field of education. As a major national plan, the digitization process of education is not only related to the quality improvement of education itself but also a crucial move to build a society and country of learning where lifelong learning is pursued by all. Against this backdrop, colleges and universities, as important positions in education, have actively responded to the call and promoted the innovative development of various works with the help of digital technology. Among them, funding education work in colleges and universities is an important link to ensure educational fairness and social justice. With the continuous increase of national and social funding for colleges and universities, the funding education system is becoming more and more mature, forming an all-round financial aid pattern with the government as the leading force and the wide participation of schools and society ^[2]. However, with the continuous development of society and the continuous innovation of science and technology, the shortcomings of the traditional funding model have gradually emerged, such as cumbersome processes, complicated materials, and so on. The in-depth integration of digital technology and funding education work in colleges and universities has greatly promoted the improvement of the funding education structure and the educational framework, helped to shape the all-round portrait of the funded students and the construction of cross-domain application scenarios, and can effectively achieve the full coverage and precise implementation of the funding, and fulfill the mission of “Three-Wide Education” in the new era. Therefore, an in-depth study of the innovative path of digital technology in funding education work in colleges and universities has extremely far-reaching practical significance and theoretical value.

2. Analysis of the current situation of digital technology empowering the funding of education work in colleges and universities

2.1. The traditional model of funding education work in colleges and universities and its limitations

In 2007, China promulgated the “Opinions of the State Council on Establishing and Improving the Financial Aid Policy System for Students from Families with Financial Difficulties in Regular Undergraduate Colleges, Higher Vocational Schools and Secondary Vocational Schools”, clearly defining the construction of a financial aid system covering “scholarships, student loans, grants, subsidies, and tuition fee reductions.” After more than ten years of implementation, this policy has effectively alleviated the educational difficulties of students from families with financial difficulties and significantly improved educational fairness. According to the “Report on the Development of Student Financial Aid in China in 2023”, in 2023, the cumulative number of students receiving financial aid across the country exceeded 160 million person-times, and the cumulative amount of financial aid reached more than 310 billion yuan. The scale of financial aid is showing a steady growth trend. However, although colleges and universities have already achieved a certain scale and stability in the investment of financial aid funds, there is still much room for improvement in using the existing financial aid resources to enhance educational effectiveness.

At present, there are problems in multiple aspects of the funding work in colleges and universities that urgently need to be solved to achieve the goals of more efficient, fair, and precise funding education. In the funding application process, most colleges and universities still rely on offline methods. When students prepare applications and supporting materials, situations such as the lack of official seals or inconsistent information often occur. The complicated materials are not only difficult to verify but also increase the burden on the staff ^[3].

Research shows that the financial aid review in colleges and universities is mostly completed within one to two months after students enroll. However, some colleges and universities may continue to delay after processes such as review, committee confirmation, and public notice. Students from extremely poor families undoubtedly bear the double pressure both economically and psychologically.

Moreover, the ways of funding education in colleges and universities also lack innovative vitality. Financial aid staff have the phenomenon of “tedious paper materials and resistance to emerging high-tech tools”, which to some extent hinders the improvement of the efficiency and quality of the funding work. In the evaluation process, the composition of evaluation groups and evaluation methods vary from one college or university to another. Most members of the evaluation groups are student cadres or roommates. Such a personnel composition is likely to lead to emotional factors interfering with rational judgment, thus resulting in unfair evaluation results. Some poor students give up applying due to the psychological pressure caused by the semi-public evaluation method, resulting in the failure of financial aid resources to accurately cover the students who really need them and forming loopholes in the work.

From a systematic perspective, the high mobility of the personnel responsible for the funding work is a major problem. In colleges and universities, counselors are often the main force in student funding work. The change in the team of counselors is likely to lead to frequent replacements of funding management personnel, seriously affecting the stability and continuity of the work. Meanwhile, although colleges and universities will adjust the funding policies according to the policies of higher authorities and actual situations, the formulation of funding management policies is still imperfect. There is a lack of clear standards for the quality requirements of funding management personnel, and there is also a lack of supervision on the standardization of the funding management process, resulting in a relatively low level of application of information technology. All these problems indicate that the funding management work urgently needs improvement and enhancement in terms of standardization and precision to serve students from families with financial difficulties better and ensure the smooth implementation and high-quality fulfillment of the funding education work.

2.2. The current application status of digital technology in the funding education work in colleges and universities

In the current era, digital technology has deeply integrated into all walks of life and has become an indispensable and crucial resource. The funding of education work in colleges and universities is no exception. With the help of digital technology, colleges and universities can conduct real-time and precise monitoring of students' economic situations, consumption behaviors, and learning trends, providing a solid basis for the timely optimization and adjustment of funding strategies. Meanwhile, it can also accurately grasp students' ideological trends, innovate the presentation forms of ideological and political resources, and enhance the effectiveness of ideological and political education. However, it cannot be ignored that although student funding work in colleges and universities has achieved remarkable results under the impetus of the information wave, some problems and shortcomings that cannot be overlooked have still emerged and urgently need to be solved to achieve the high-quality development of the funding education work.

With the rapid development of information technology, the funding work in colleges and universities has accumulated a large amount of data, covering multiple dimensions such as students' family economic situations and consumption patterns. However, due to the complex and diverse data sources and the poor compatibility between the funding information system and the information systems of other departments within the university,

it is difficult to comprehensively and accurately assess students' actual needs, which increases the complexity of the funding work ^[4]. Digital technology, as a key means and effective approach to achieving precise funding, is of self-evident importance. However, there are still deficiencies in the depth and effectiveness of precise funding at present. Colleges and universities have a single method for analyzing funding data and fail to dig deeply into the information and correlations behind the data, resulting in a lack of scientific argumentation and data support for funding education decisions, unable to meet the diverse needs of students or fully exert the maximum effectiveness of funding education. In the information environment, the student funding work has made certain progress in aspects such as the precise identification of funded students, the accurate input of data information, and the precise distribution of funding funds. However, the work in aspects such as psychological counseling, spiritual care, ability improvement, and the cultivation of a sense of responsibility for funded students is relatively weak, and a complete and systematic training system has not yet been formed. This unbalanced development trend has seriously hindered the comprehensive realization of the goal of precise funding. In addition, against the backdrop of the wide application of digital technology, the issues of the security and privacy protection of students' data have become increasingly prominent and have become a key problem in funding education work. Moreover, colleges and universities have limited technical levels in key links such as data collection, storage, and analysis, and the reserve of professional talents is also relatively scarce, which has largely restricted the in-depth application and innovative development of digital technology in the practice of funding education and has become one of the bottlenecks for colleges and universities to improve the quality of funding education.

All in all, colleges and universities must face these problems squarely, actively take effective measures, strengthen technological research and development as well as talent cultivation, optimize the data management and analysis system, reinforce the mechanism for protecting students' privacy, and continuously improve all aspects of the funding education work. Only in this way can the great potential of digital technology in the field of funding education in colleges and universities be fully unleashed, and the scientific, precise, and efficient development of the funding education work be achieved, thus providing a powerful guarantee for students' growth and success.

3. The innovative path of digital technology empowering the funding of education work in colleges and universities

3.1. Building a panoramic view of the funding education system and optimizing the management process path

The concept of the value of big data expounded by Viktor Mayer-Schönberger in his book "Big Data: A Revolution That Will Transform How We Live, Work, and Think" makes researchers realize that big data is not only a technical means, but also a manifestation of innovative thinking and powerful cognitive abilities, namely "big data thinking" and "big data skills". In the work of funding education in colleges and universities, the application of such thinking and skills is of crucial importance. Establishing a sound funding information system is the foundation for the application of digital technologies. Building a unified and standardized data platform can promote data interaction and circulation among various departments within the school, achieve data sharing, and provide all-round and in-depth data support for the work of funding education, thus solidifying the foundation for the scientific formulation and precise implementation of funding policies ^[5].

Firstly, this funding information system can systematically integrate key data such as student's basic information, academic performance, and family economic status. By analyzing these data, it can gain insights into students' real needs and existing problems, providing a reference basis for formulating personalized funding plans.

For example, if data analysis indicates that students in a particular region generally have mental health problems, more resources for mental health education can be allocated in the funding plan ^[6]. In addition, the system can collect feedback information and effectiveness evaluation data after students participate in funding activities, to optimize and adjust the existing assistance measures promptly. For instance, through a detailed analysis of the actual situation of students participating in work-study programs, it can identify which work-study positions are more popular among students and which aspects still need to be improved urgently, making the funding work more in line with students' actual needs and development expectations.

It is worth mentioning that with the help of new media platforms, students can complete funding applications online, including filling in forms and submitting relevant materials. The simplification of this process has greatly improved the convenience and efficiency of funding applications ^[7]. Meanwhile, teachers and reviewers can also complete the approval work online through these platforms, which not only improves the efficiency of approval but also makes the approval process more transparent ^[8]. Moreover, the system can also be used to promptly announce the progress and effectiveness of funding projects, greatly increasing the openness and transparency of the projects and further enhancing students' satisfaction and recognition of the funding work.

3.2. Improving the structure of the funding education system and enhancing the effectiveness of precise funding

The core essence of the funding education system lies in ensuring the fair distribution of educational resources, stimulating students' internal motivation, and promoting their all-round growth ^[9]. To strengthen the effectiveness of the funding management system, the top priority is to build a complete and rigorous application, review, and distribution process to accurately identify the students who truly need funding and allocate the funding amounts reasonably ^[10]. Meanwhile, supervision over funds should be strengthened, a sound supervision mechanism should be established to put an end to the abuse of funds. In addition, efforts should be focused on strengthening the comprehensive evaluation and effective monitoring of the funding education work. Diversified scientific methods such as data analysis and questionnaire surveys should be fully utilized to conduct a comprehensive assessment of all aspects and the overall effectiveness of the funding work, to detect and solve problems promptly. The intensity of publicity and education work should be increased to enhance teachers' and students' awareness and understanding of funding education and promote the standardization and sustainable development of the funding work.

Given the complexity of university funding work, precise positioning and customized services have become the key breakthroughs. Make full use of digital technologies to optimize the identification standards and processes for students with financial difficulties in their families, and achieve all-round precision in funding. By collecting and deeply analyzing data on students' academic performance, living conditions, and mental states at various stages, a comprehensive profile of the assisted students can be drawn to achieve precise screening. For example, through online surveys and other means, the needs of students with financial difficulties can be grasped, relevant funding information such as scholarships and grants can be pushed to them in a timely and precise manner, and suitable part-time and internship opportunities can be recommended. For students with academic difficulties, take full advantage of the online education platform to provide them with a rich variety of online tutoring courses and learning resources ^[11]. For students with heavy psychological burdens, various online psychological counseling methods such as text and video can be used to provide them with professional psychological support ^[12]. In addition, universities should also implement precise funding according to students' individualized needs, whether it is the distribution of scholarships and grants or the arrangement of work-study programs, which should be

precisely aligned with students' actual situations to maximize the effectiveness of the funding work. Meanwhile, the real-time update and dynamic adjustment functions of digital technologies can keenly sense changes in students' situations and flexibly adjust the funding plans to ensure that the funding work can always closely meet students' actual needs and provide a powerful guarantee for students' growth and success^[13].

3.3. Deepening the practical results of funding education and empowering students' diversified growth

Under the educational background of the new era, colleges and universities have constructed a brand-new funding education model, which highly integrates poverty alleviation, aspiration cultivation, and intelligence enhancement, and digital technology plays a key role in this process. This model is not only manifested in providing students with necessary financial support but also in careful spiritual cultivation and effective ability improvement. On the one hand, it effectively alleviates the economic pressure and provides a material guarantee for students' studies; on the other hand, it constructs a comprehensive support and education framework, provides students with diversified and personalized assistance and support means, and promotes the all-round development of students^[14].

While providing economic support for students, colleges and universities should make full use of the combination of online and offline methods and actively offer rich and diverse training courses. These courses closely focus on the professional fields of students and aim to teach practical and cutting-edge professional skills. Students can flexibly and independently choose to participate in training courses according to their own study and life schedules, and then have a thorough understanding of the employment market demand dynamics of the industry they are in^[15]. Based on an accurate grasp of the market, students can formulate personal learning plans and strategies to cope with market changes, thus effectively improving their career planning ability and adaptability in the complex and changeable market environment, and laying a solid foundation for future career development. For example, by using digital technology to establish an online psychological counseling system, many deficiencies in traditional offline psychological counseling, such as time and space limitations and students' concerns, can be overcome^[16]. Through the combination of online and offline channels, customized psychological counseling services are provided to students to enhance their psychological resilience and health level. This comprehensive psychological support is beneficial to students' subsequent academic exploration and smooth integration into society. At the same time, inspiring model figures to participate in the publicity activities of typical and touching cases of sponsorship, giving full play to the main role of students in the process of sponsorship and education, inspiring the enthusiasm of more students through the power of examples, cultivating a large number of model leading figures, realizing the positive transformation from "being sponsored" to "sponsoring others", and making the effectiveness of funding education take root.

3.4. Strengthening the supervision barrier and safeguarding the fairness and justice of funding education work

Transparency and fairness are the lifelines of the funding education work in colleges and universities. In the era of new media, colleges and universities should make funding information fully public, including the interpretation of funding policies, application requirements, review processes, and the publicity of results, to ensure that the information is fairly and openly accessible so that students and parents can consult it at any time and to ensure that every student can obtain funding in an equal and fair environment^[17]. For example, when publicizing the review results, an anonymous method can be adopted for release. This can not only fully respect and protect students'

personal privacy but also effectively safeguard the fairness and objectivity of the results, and avoid unnecessary disputes and misunderstandings, thereby winning more trust and support from students and parents and motivating students to participate in funding activities actively.

Moreover, colleges and universities should continuously strengthen the supervision of funding work, and build a scientific evaluation system to ensure the effective implementation of funding policies ^[18]. With the help of digital technologies, monitor the flow and usage of funding funds in real time, establish and improve convenient and efficient reporting and appeal mechanisms, and encourage teachers and students to actively participate in supervision to correct all kinds of problems emerging in the funding work promptly and ensure the smooth progress of the funding work. While strengthening the management of funding work, colleges and universities cannot neglect the ideological and political education of the assisted students, which is of great significance for improving their self-management abilities and comprehensive qualities ^[19]. Through the dynamic monitoring of digital technologies, track and evaluate the effectiveness of the funding education work in real-time and solve potential problems promptly. Most importantly, colleges and universities must build a strict and reliable digital technology management system to effectively ensure that the security and privacy of students' personal information are not violated. In all aspects such as data collection, storage, and use, it is necessary to strictly follow the requirements of laws and regulations, and implement comprehensive and meticulous information security management measures to ensure the legality, integrity, and confidentiality of data ^[20]. Simultaneously, continuously strengthen technical protection, enhance the reserve of technical strength and the construction of talent teams, and focus on improving the ability and quality of counselors. Through carrying out systematic and comprehensive training, give full play to the role of counselors as a bridge and bond in student funding work and make the funding education work solid and detailed.

4. Conclusion

The continuous development of digital technology has brought broad development space and innovative opportunities for funding education work in colleges and universities. Against this backdrop, if colleges and universities want to give full play to the advantages of digital technology, they must unswervingly promote innovative practices and continuously optimize work models and methods. To promote the funding education work to achieve high-level development, efforts need to be made in multiple key aspects: building a panoramic view of the funding education system and optimizing the management process path; improving the structure of the funding education system and enhancing the effectiveness of precise funding; deepening the practical results of funding education and empowering students' diversified growth; strengthening the supervision barrier and safeguarding the fairness and justice of funding education work. Meanwhile, educators should be clear that although digital technology has powerful functions and great potential, it is just an auxiliary tool in funding education work in colleges and universities. How to skillfully and efficiently use this tool, closely combine it with the actual situation of the funding education work in colleges and universities, give full play to its advantages, and avoid falling into the misunderstanding of putting technology above everything else has become a key issue. This requires colleges and universities to have an in-depth understanding of the characteristics, needs, and challenges of their funding education work in the practice process, accurately position the application of digital technology on the main points and difficulties in the actual work, and through continuous attempts, adjustments, and optimizations, achieve the in-depth integration of digital technology and the funding education work to achieve the best work results.

Given this, colleges and universities still have a long way to go in the exploration and practice of the field of funding education. They need to continuously maintain the enthusiasm for learning and the spirit of innovation, closely follow the development pace of the digital era, constantly adapt to the new requirements and challenges put forward by the times, and actively explore new models of funding education that are more scientific, efficient, precise and warm-hearted, to contribute to the cultivation of socialist builders and successors with all-round development in morality, intelligence, physique, aesthetics, and labor.

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Study on the Effect of Mixed Strains of Bacteria on the Fermentation Quality of Natto Beans

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Abstract: During the fermentation process of natto, the decomposition of soy protein by *Bacillus subtilis* produces ammonia-nitrogen-like substances, resulting in a finished product with an ammonia-fishy odor, which affects consumer acceptance. In this study, *Bifidobacterium bifidum*, *Lactobacillus lactis*, and *Bacillus subtilis* were mixed for natto fermentation experiments, respectively, aiming to improve its flavor characteristics. The experimental results showed that fermentation with mixed strains significantly changed the volatile matter composition of natto. Among them, the electronic nose analysis showed that the content of nitrogen oxides and inorganic sulfides increased significantly in the fermented samples, while the ammonia nitrogen species decreased relatively. In addition, the amino acid analyzer test revealed that the total amount of free amino acids was significantly increased after fermentation of the mixed strains, while several flavor-improving amino acids also occupied a larger proportion. The experimental results indicated that the addition of *Bifidobacterium* and *Lactobacillus* could effectively regulate the metabolites during natto fermentation, reduce the ammonia-fishy odor, and improve the fermentation quality, which has potential application value.

Keywords: *Bifidobacteria*; *Lactobacillus*; *Bacillus subtilis*; Natto; Fermentation quality; Amino acids

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1. Introduction

1.1. Origin and nutrition of natto

Natto is a traditional fermented soybean product, usually made by fermenting soybeans with *Bacillus subtilis*. It has a unique flavor and viscosity, and not only retains the nutritional value of soybeans but also improves the digestibility and absorption of proteins. Under the action of microorganisms, natto produces a variety of physiologically active substances, such as nattokinase, soybean flavonoids, phytosterols, superoxide dismutase, and several biologically active peptides from raw soybeans, and regular consumption of natto improves immunity and physical fitness^[1]. However, during the fermentation process of natto, due to the hydrolysis of rich soy protein under the action of protease, ammonia nitrogen-like substances with ammonia fishy odor are often produced, of

which the ammonia taste and bitter taste are often difficult for people to accept^[2].

1.2. Research conception

Bacillus subtilis is a subspecies of *Bacillus subtilis*, which is the main microorganism for fermentation of natto at home and abroad. The secreted extracellular protease and other extracellular enzymes can decompose various macromolecules to produce various nutrients and physiologically active substances with healthcare functions^[3].

Bifidobacteria are important beneficial microorganisms in the intestinal tract. As beneficial microorganisms, Bifidobacteria have biological barriers, nutritional support, anti-tumor and immune-enhancing effects on human health, improve the function of the gastrointestinal tract, and can also play an anti-aging role^[4].

Lactobacillus is a collective term for bacteria that can utilize fermentable carbohydrates to produce large amounts of lactic acid. It can improve the function of the human gastrointestinal tract, restore the balance of bacterial flora in the human intestinal tract, form antimicrobial biological barriers, maintain human health; regulate immunity, and can enhance human immunity and resistance^[5].

1.3. Research conception

The flavor is an important factor affecting the quality and value of food, and in natto, the flavor of natto has been the focus of research because of the special ammonia-fishy odor^[6-8]. The flavor of natto mainly depends on microorganisms and fermentation conditions, and the formation of flavor substances is a complex and variable biochemical process. In recent years, there have been a lot of studies on improving the flavor of natto, mainly using the following methods: raw material screening and matching, strain screening, strain improvement, mixed-bacteria fermentation, control of fermentation conditions, seasoning, and freeze-drying, etc. All of these methods can, to a certain extent, play a great role in the improvement of the flavor and quality of natto^[9-11].

During the fermentation of natto, due to the hydrolysis of rich soy protein under the action of protease, ammonia and nitrogen-like substances with ammonia-fishy odor are often produced, and most of these substances are alkaline compounds. In this experiment, *Bifidobacterium bifidum*, *Bacillus subtilis*, and *Lactobacillus* single and mixed bacteria were utilized to ferment natto. It is hoped that the various flavor substances and acidic components produced by the fermentation of *Lactobacillus* and *Bifidobacterium* lactis, such as lactic acid and acetic acid, can be neutralized with alkaline compounds acid and alkaline to a certain extent, thus alleviating the undesirable odors of the natto, and at the same time enriching the flavor qualities of the natto.

2. Materials and methods

2.1. Experimental materials

2.1.1. Bacterial strains

100 g of each of *Bifidobacterium bifidum*, *Bacillus subtilis*, and *Lactobacillus* were purchased and stored in a refrigerator at 4°C in the freezer for spare use (Production company: Xi'an Jushengyuan Biotechnology Co., Ltd., China), as shown in **Figure 1**. For convenience, KC stands for *Bacillus subtilis*, SQ stands for *Bifidobacterium bifidum*, and RS stands for *Lactobacillus* in the following experiments.



Bacillus subtilis



Bifidobacteria



Lactobacilli

Figure 1. Experimental strains of bacteria

The organic soybeans (Origin: Jilin, China Grade: Grade I) used are shown in **Figure 2**.



Figure 2. Experimental soybean

2.1.2. Experimental apparatus

Natto fermenter (Model: RS-G29 Brand: Rongshida, China)

Pulverizer (Model: LL-A Brand: Liren, China)

Incubator (Model: Huaguan Digital Oscillation Incubator, China)

Automatic amino acid analyzer (Model: L-8900, China)

Electronic Nose (Model PEN3 from AIRSENSE, Germany)

Digital Food Thermometer (Wenzhou Mittel Intelligent Technology Co., Ltd., China)

2.2. Methods

2.2.1. Pre-treatment of bean seeds

- (1) Selection: Pick out the beans that are half, peeled, scabbed, and other conditions, and keep the soybeans that have bright outer skin color, clean skin, and full and neat grains (**Figure 3**).
- (2) Cleaning: Wash with water more than three times, until the water color is clear
- (3) Soaking: Soak in water at 19°C water temperature for 12 hours.



Figure 3. Pre-processing

2.2.2. Fermentation experiment of natto beans

Soaked soybeans were divided into conical flasks according to 200 g per portion, covered with a sealing film, and sterilized in an autoclave at 121°C for 20 minutes (Figure 4). After removal, it was placed on the ultra-clean bench to dry to room temperature.



Figure 4. Samples of natto to be fermented

According to the preparation method in the table below (Table 1), the bacterial powder was weighed separately and dissolved in 10 ml of sterile water to prepare a single bacterial solution and mixed well.

Table 1. Bacterial solution preparation table

Sample No.	Strain and amount of bacteria added		
	<i>Bifidobacterium bifidum</i> (g)	<i>Bacillus subtilis</i> (g)	<i>Lactobacillus</i> (g)
KC	0	3	0
SQ	3	0	0
RS	0	0	3
KC-SQ-1	1	3	0
KC-SQ-2	2	3	0
KC-SQ-3	3	3	0
KC-RS-1	0	3	1
KC-RS-2	0	3	2
KC-RS-3	0	3	3

2.2.3. Sensory evaluation test of natto samples

The fermented natto samples were subjected to preliminary sensory observations in five aspects: color, aroma, taste, length of pull, and amount of mucus.

2.2.4. Electronic nose testing experiment

The samples were homogenized and sent to the Beijing Food Research Institute for testing. The electronic nose took readings every 1s through 10 sensors for the 10 main volatile substances in **Table 2** for a total of 90s consecutive readings.

Table 2. Table of main substances measured by different sensors

Sensor name	Main detected substances
W1C	Aromatic ingredients
W5S	Nitrogen oxides
W3C	Ammonia
W6S	Hydrides
W5C	Short-chain alkanes
W1S	Methyls
W1W	Inorganic sulfides
W2S	P-alcohols, aldehydes and ketones
W2W	Organic sulfides
W3S	Long-chain alkanes

2.2.5. Detection of free amino acids in natto

After the samples were crushed and homogenized, they were sent to the laboratory of the Beijing Academy of Agricultural and Forestry Sciences for testing the free amino acid content of natto using the fully automatic amino acid analyzer method with reference to the national standard of GB/T30987-2020 “Determination of Free Amino Acids in Plants” in China.

3. Results and analysis

3.1. Sensory evaluation

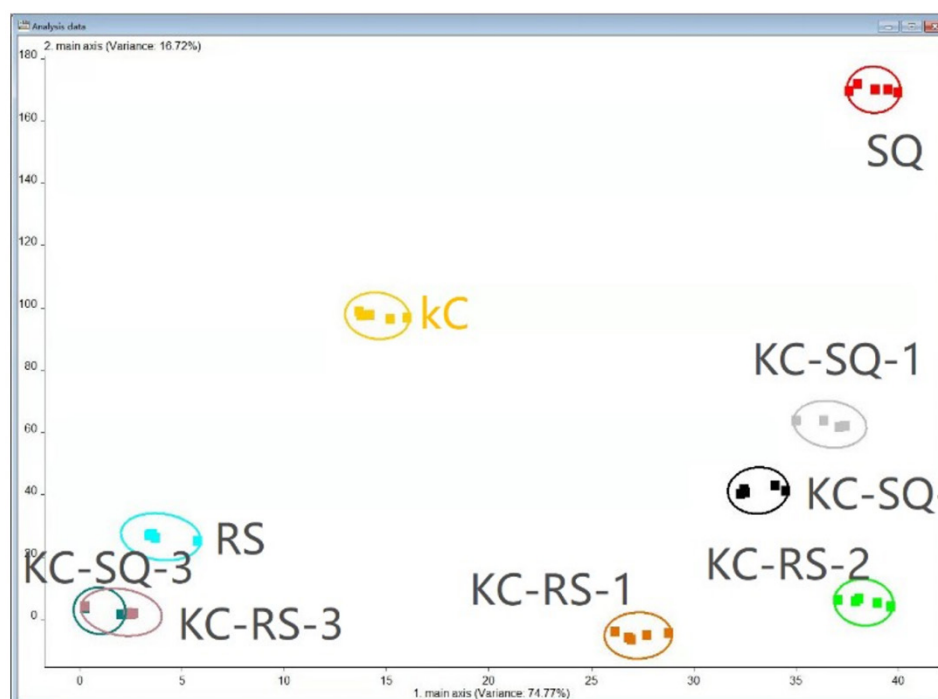
From **Table 3**, it can be seen that when a single strain was fermented, *Bifidobacterium bifidum* was better than *Bacillus subtilis* and *Lactobacillus* in terms of color, taste, and all aspects, the length of the draw was longer and there was more mucus. However, the ammonia smell was heavier. When the ratio of *Bacillus subtilis* and *Bifidobacterium bifidum* was 1:1, the color was improved, the surface was glossy, and the taste was changed, but at the same time, the ammonia smell was aggravated. When *Bacillus subtilis* and *Lactobacillus lactis* were paired in the ratio of 1:1 the ammonia smell was reduced, which indicated that the mixed-bacteria fermentation could significantly improve the flavor and color of the natto, but it did not have much effect on the taste, drawing, and mucus effect of the fermented natto.

Table 3. Effect of fermentation of three bacteria on the quality of natto beans

Strain	Color	Incense	Flavor	Wire drawing	Mucous
SQ	Bright color, shiny skin	Heavy ammonia odor	Softer, wetter, slightly bitter aftertaste	12–20	More
KC	Dull color, no luster	General ammonia odor	Softer, drier, more bitter aftertaste	6–10	General
RS	Dull color, no luster	A little ammonia.	Softer, drier, more bitter aftertaste	0–5	No
KC-SQ mixing	Bright color, shiny skin	Heavy ammonia odor	Softer, wetter, slightly bitter aftertaste	6–15	More
KC-RS mixing	Bright color, shiny skin	A little ammonia.	Softer, wetter, slightly bitter aftertaste	0–5	General

3.2. Evaluation of electronic noses

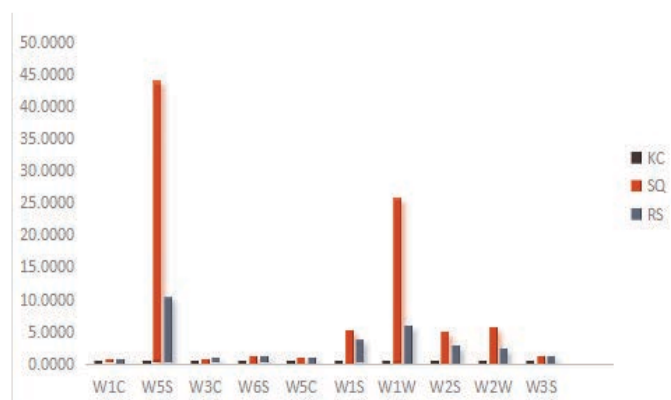
As shown in **Figure 5**, the odor signal data of natto samples detected by the electronic nose were analyzed by PCA, and the 0-coordinate boundaries of the two principal components were taken as the axes to show that the natto fermented with different strains was in a dispersed state, and except for the mixture of *Bacillus subtilis* with *Lactobacillus* and *Bifidobacterium bifidum* 1;1, there was an intersection of the detected odors, and the other components of the mixed-strain components were more dispersed than those of the single component, which indicated that the natto fermented with the mixed strain had a significant difference from that of the single component in terms of the odors. This shows that a single component had a significant difference.

**Figure 5.** PCA of odor characteristics of fermented natto with different strains of bacteria

As can be seen in **Figure 6**, by analyzing the fermented natto of three single fractions of *Bacillus subtilis*, *Bifidobacterium bifidum*, and *Lactobacillus lactis* through the electronic nose, it can be seen that, for the content of two types of substances, nitrogen oxides (W5S) and inorganic sulphides (W1W), *Bifidobacterium bifidum* was significantly higher than *Bacillus subtilis* and *Lactobacillus lactis*, and it is initially judged that *Bifidobacterium bifidum* produces special gases under the action of anaerobiosis (**Table 4**).

Table 4. Evaluation of single-strain fermented natto e-nose

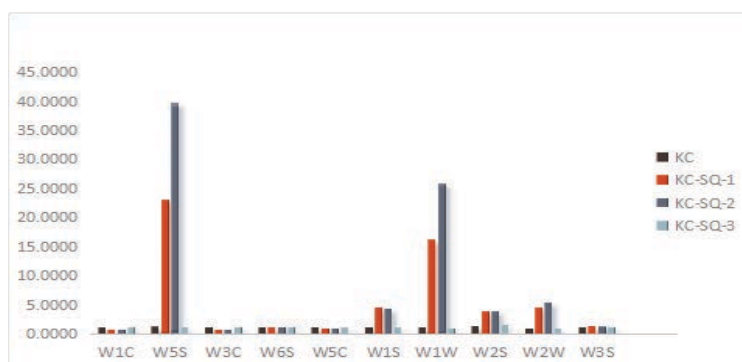
	W1C	W5S	W3C	W6S	W5C	W1S	W1W	W2S	W2W	W3S	
KC	0.4582	0.4582	0.4582	0.4582	0.4582	0.4582	0.4582	0.4582	0.4582	0.4582	AVG
SQ	0.5678	43.9647	0.6784	1.1106	0.9451	5.2652	25.7794	4.9617	5.6848	1.2155	AVG
RS	0.6298	10.2546	0.7789	1.0420	0.9638	3.6339	5.9424	2.8392	2.3592	1.2359	AVG

**Figure 6.** Electronic nose analysis of single-strain fermented natto

As can be seen in **Figure 7**, the results of analyzing the mixture of *Bacillus subtilis* and *Bifidobacterium bifidum* according to different ratios by the electronic nose revealed that for the contents of two types of substances, nitrogen oxides (W5S) and W1W (inorganic sulphides), when the ratio of *Bifidobacterium bifidum* to *Bacillus subtilis* reaches 2:3, the measured concentration is significantly higher than that of *Bifidobacterium bifidum* to *Bacillus subtilis* with the ratios of 1:3 and 1:1 (**Table 5**).

Table 5. Mixed strains for fermentation of natto e-nose

	W1C	W5S	W3C	W6S	W5C	W1S	W1W	W2S	W2W	W3S	
KC	0.9811	1.1937	0.9887	1.0072	0.9883	1.0763	1.0568	1.3578	0.9240	1.1326	AVG
KC-SQ-1	0.5700	23.1542	0.6931	1.0399	0.9453	4.5912	16.1879	3.7403	4.4268	1.2451	AVG
KC-SQ-2	0.6258	39.6239	0.7181	1.0762	0.9454	4.3552	25.8619	3.8373	5.3190	1.1836	AVG
KC-SQ-3	1.0373	1.1507	1.0355	1.0212	0.9943	1.1122	0.9124	1.4363	0.7743	1.1431	AVG

**Figure 7.** Comparison of e-nose assay after mixed fermentation

As can be seen in **Figure 8**, when *Bacillus subtilis* and *Lactobacillus* were mixed, the content of both nitrogen oxides (W5S) and inorganic sulfides (W1W) appeared to increase significantly, and when the ratio of *Lactobacillus* to *Bacillus subtilis* reached 1:3, the measured concentrations were significantly higher than the ratio of *Lactobacillus* to *Bacillus subtilis* of 2:3 and 1:1 (**Table 6**).

Table 6. Evaluation of *Bacillus subtilis* and *Lactobacillus* hybrid strains for fermentation of natto e-nose

	W1C	W5S	W3C	W6S	W5C	W1S	W1W	W2S	W2W	W3S	
KC	0.9811	1.1937	0.9887	1.0072	0.9883	1.0763	1.0568	1.3578	0.9240	1.1326	AVG
KC-RS-1	0.5311	62.3764	0.6383	1.0624	0.9364	5.0098	27.9089	4.4150	6.1031	1.2112	AVG
KC-RS-2	0.6110	46.8356	0.7030	1.1231	0.9396	4.7436	26.1585	4.7252	5.4600	1.2065	AVG
KC-RS-3	0.6039	37.1963	0.7104	1.0608	0.9474	4.3427	23.4015	3.8464	5.0550	1.1975	AVG

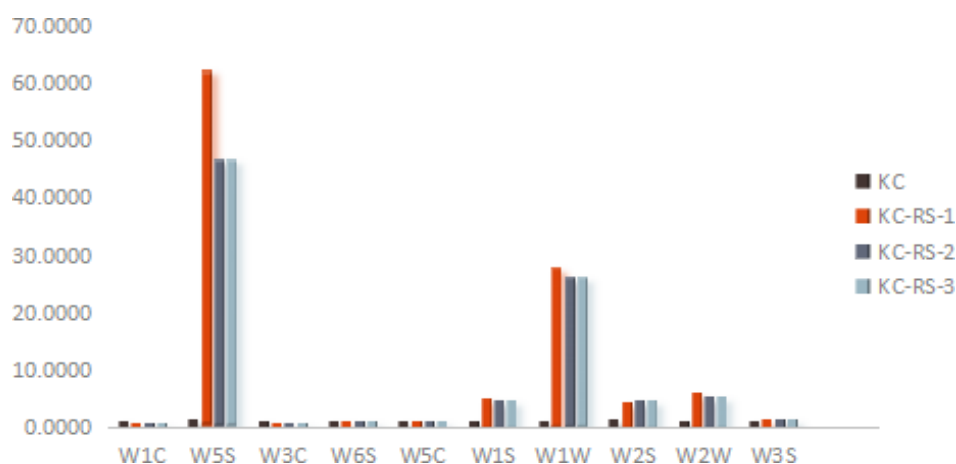


Figure 8. Flavor analysis of mixed fermentation of *Bacillus subtilis* with lactic acid bacteria

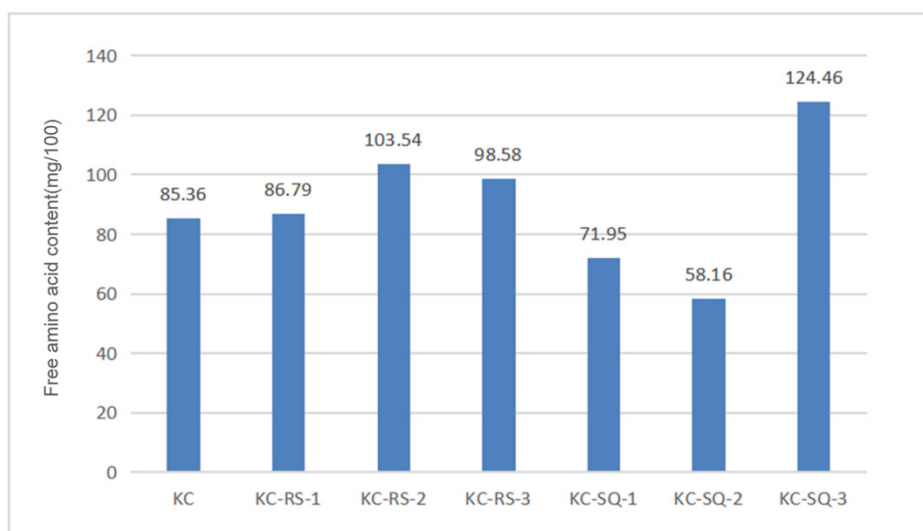
3.3. Free amino acid composition analysis

From **Figure 9**, it can be seen that the overall total amount of amino acids in natto fermented with mixed strains was higher than that in natto fermented with *Bacillus subtilis* alone, and the content of free amino acids in natto fermented with a 1:1 mixture of *Bifidobacterium bifidum* and *Bacillus subtilis* when fermented with a mixed strain was also higher than that of the amino acid content of the mixture of strains with other ratios. As can be seen from **Figure 10**, the proportion of essential amino acids accounted for by the single-strain fermented natto was higher than that of the mixed-strain fermented natto, indicating that the total amount of amino acids was improved by the mixed fermentation, but it did not improve the content of essential amino acids (**Table 7**).

The sensory quality of food is closely related to the type and content of amino acids ^[13–14]. There are still great differences in the flavor presentation of different kinds of amino acids. Glutamic acid and aspartic acid are important fresh-flavored amino acids, especially glutamic acid, the sodium salt of which is the main ingredient of MSG used in daily life, and the addition of bifidobacteria and lactobacilli increased the content of both glutamic acid and aspartic acid, and glycine and alanine presented a sweet flavor ^[15]. These four amino acids account for about 50% of the total free amino acids in the mixed fermented natto and have a positive effect on the taste improvement of fermented natto.

Table 7. Compositional analysis of free amino acids in samples (unit: mg/100g, essential amino acids:*)

Aspect \ Sample number	KC	RS	SQ	KC-RS-1	KC-RS-2	KC-RS-3	KC-SQ-1	KC-SQ-2	KC-SQ-3
Aspartic acid	5.1	8.96	6.12	5.11	7.09	7	1.68	0.77	3.6
Serine	2.38	3.11	7.35	0.96	0.71	0.97	1.64	0.37	4.05
Glutamic acid	19.84	43.82	49.55	34.12	42.63	40.48	23.09	11.68	37.85
Glycine	2.2	3.16	4.54	2.03	2.89	2.82	3.26	3.03	4.16
Alanine	9.3	8.72	13.96	8.91	9.69	9.09	6.62	4.94	13.08
Tyrosine	1.36	5.42	5.23	2.76	4.56	4.49	1.74	0.22	7.51
Arginine	tr	0.82	0.77	0.69	1.15	1.33	2.19	15.07	8.31
Proline	5.34	5.45	4.29	6.51	6.78	5.59	4.99	4.55	5.18
**Threonine	2.45	1.48	5.25	1.23	1.23	1.31	1.59	0.5	4.19
*Valine	16.11	10.47	3.16	12.33	11.84	11.09	12.82	9.09	0.96
Methionine	1.39	0.52	4.19	0.64	0.54	0.63	1.1	0.4	3.08
*Isoleucine	2.6	0.51	6.02	1.69	0.78	0.71	1.83	2.12	4.34
*Leucine	7.36	1.56	21.37	1.29	1.19	1.54	2.33	0.17	8.59
*Phenylalanine	2.65	6.3	13.49	3.33	4.57	4.53	2.11	0.39	9.8
*Lysine	6.77	4.97	19.96	4.04	5.92	5.18	4.5	4.53	8.16
Histidine	0.51	2.07	2.64	1.15	1.97	1.82	0.46	0.33	1.6
Total acids	85.36	107.34	167.89	86.79	103.54	98.58	71.95	58.16	124.46
Non-essential Amino Acids/%	53.30%	74.00%	54.70%	70.40%	72.90%	72.80%	62.80%	69.90%	67.30%
* Essential Amino Acids/%	46.70%	26.00%	45.30%	29.60%	27.10%	27.20%	37.20%	30.10%	32.70%

**Figure 9.** Comparison of amino acids between single and mixed strains of bacteria

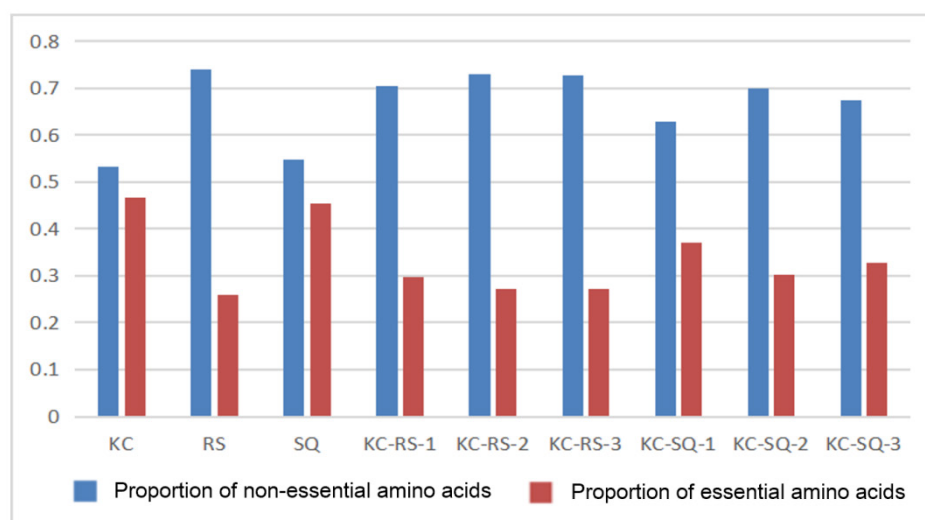


Figure 10. Proportion in fermented natto with single and complex strains of bacteria

4. Conclusion

The ammonia-fishy odor of its natto can be changed and the fermentation quality can be improved by mixing *Bacillus subtilis* with *Lactobacillus* and *Bifidobacterium* in different ratios for fermentation.

Firstly, mixed-strain fermentation increased the total free amino acids, but there was no significant change in the proportion of essential amino acids.

Secondly, the taste of the mixture was indeed significantly different from the fermentation of a single strain as detected by the electronic nose.

Thirdly, the amino acid content of the mixed fermentation portion was increased, which had a positive effect on the improvement of taste.

It can be concluded that various flavor substances and acidic components such as lactic acid and acetic acid produced by fermentation of lactobacilli and bifidobacteria can be neutralized to a certain extent with alkaline compounds, thus reducing the bad odor of natto and at the same time enriching the flavor components of natto.

Disclosure statement

The authors declare no conflict of interest.

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Analysis of Factors Influencing Work Fatigue of Online Workers in Manufacturing Enterprises and Research on Countermeasures

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Abstract: With the rapid development of the manufacturing industry, work safety issues in the manufacturing industry have also begun to enter people's vision, and job fatigue is one of the important influencing factors. To explore the influencing factors of occupational fatigue among online workers in manufacturing enterprises, subjective questionnaire surveys and field observations were used to collect research sample data. SPSS 26.0 software was used to analyze the validity of the obtained sample data, and five influencing factors were extracted: operators, the work itself, the work environment, work equipment, and enterprise management. A structural equation model of the influencing factors of occupational fatigue among online workers in manufacturing enterprises was constructed, and AMOS 24.0 software was used for factor analysis. The research results show that the degree of impact on job fatigue of online workers in the manufacturing industry is in the following order: work environment (B)>work equipment (F)>enterprise management (M)>work itself (O)>work personnel (D). Finally, propose targeted policy recommendations based on the degree of impact.

Keywords: Manufacturing homework fatigue; Influencing factors; Structural equation model

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1. Introduction

The manufacturing industry is the main body of the national economy, the tool of the country, and the foundation of the country. With the continuous improvement of production technology and equipment level, China's manufacturing industry is going all out to automation, mechanization, and intelligent development. The "Made in China 2025" pointed out that "people-oriented" is the foundation of China's construction of manufacturing power, only to improve the status of "people" in the production system, give full play to the function of "people", and use "people" to manipulate the machine, can ensure the long-term healthy and stable development of manufacturing. However, the process of development is gradual, as in the actual production activities, there is still a lot of manual work, which increases the work intensity of workers in the manufacturing industry, and the fatigue phenomenon

of workers will rise, which will not only cause a decline in production efficiency but also increase the incidence of production accidents. Therefore, analyzing the work fatigue of workers in manufacturing enterprises and exploring the driving strength of different influencing factors on the work fatigue of online workers in the manufacturing industry has certain practical significance for solving the actual work fatigue problem in the manufacturing industry.

By combing the frontier trends in this field, it is found that the current research mainly focuses on the evaluation of work fatigue, the influencing factors of work fatigue, and the improvement of work fatigue. Since the late 1800s, scholars have used the erasure test to measure attention and fatigue in subjects, Work efficiency began to be used as an evaluation index of cancellation test to laterally characterize fatigue degree ^[1]. Subsequently, human physiological characteristics began to be included in the fatigue evaluation index system ^[2]. With the continuous deepening of research and the continuous development of science and technology, high-tech equipment began to be put into the field of fatigue evaluation. In the automotive field, computer vision systems began to be applied to analyze the fatigue degree of drivers, and the application of this technology provided a new perspective for the improvement of fatigue evaluation methods ^[3]. With the rapid development of the industry worldwide, some scholars began to focus their research perspectives on workers, self-diagnosis questionnaires, multidimensional fatigue scales (MFI-20) ^[4]; Modified fatigue scale (FAI) ^[5]; and Body and Brain Fatigue Evaluation Scale ^[6], a series of fatigue evaluation scales have been widely used, and later some scholars have based on the physical characteristics of workers ^[7]. For example, biochemical indicators such as eye movement frequency and blood pressure are combined with the Perclos method to obtain the fatigue state of the subjects, which can effectively avoid the interference of human subjective factors and provide a scientific basis for the physiological fatigue caused by research work.

It is generally believed that the influencing factors of job fatigue can be divided into two parts: physiological factors and psychological factors, both of which can affect job fatigue. Some scholars have pointed out in their research that the physiological conditions of the workers as the restricting factor, there is a significant positive correlation between working time, working intensity, and job fatigue, indicating that there is a certain relationship between physiological factors and job fatigue ^[8]. Later, when studying the order-picking operation, it was found that human psychological factors had a great impact on the efficiency of the picking operation, and mental fatigue seemed to have a negative impact on the operation effect ^[9]. With the deepening of research, scholars began to study the influencing factors of job fatigue from different perspectives. Some scholars proposed that job fatigue is the result of the influence of both managers and operators ^[9]. Subsequently, through the research on diver fatigue, the relationship between individual fatigue and team management was also found ^[11]. Other scholars have also conducted a large number of studies on the job fatigue of migrant workers, university teachers, and brain-based practitioners ^[12–14].

The work fatigue improvement is based on the theory of human factor engineering, and the improvement plan is implemented to improve work efficiency. Some scholars focus on objective mathematical models or theoretical methods for improving job fatigue, such as fatigue risk management systems (FRMS), quantile and linear regression models, mixed integer linear programming (MILP), and so on ^[15–17]. The appearance of these mathematical models provides a reference for solving the fatigue problem existing in the actual situation. Some scholars study fatigue improvement from a realistic perspective, exploring the root causes of fatigue from the aspects of operators, environment, equipment, etc. Some scholars analyze the workshop environment of small and medium-sized enterprises, point out that there are widespread problems such as poor lighting and serious noise pollution in enterprises, and put forward targeted suggestions for improvement ^[18]. Based on the ergonomic theory, some scholars

have revealed the main causes of fatigue among current VDT workers, and proposed design opportunities and future development of ways to alleviate such human fatigue from the perspective of industrial design^[19].

To sum up, although there are many researches on the influencing factors of job fatigue, most of them focus on the fields of transportation, sports, medicine, etc. There is little research on the influencing factors of job fatigue of online workers in the manufacturing industry, and the research on the influencing factors of job fatigue is not systematic. The different labor operations and workers' conditions of different enterprises should be considered in the research. In practice, it is necessary to analyze the actual situation. Given this, this paper adopts a questionnaire survey to collect the actual data of enterprises and uses the SEM structural equation model to explore the weight of various influencing factors on job fatigue, to put forward targeted policy suggestions.

2. Research methods and indicators

2.1. SEM structural equation model

The structural equation model (SEM) is a method commonly used in social science research to analyze causality (observed variables versus potential variables, and between potential variables). Work fatigue is affected by many factors at the same time, and its evaluation indicators are difficult to quantify. Moreover, due to the large sample size collected by the questionnaire, errors in data processing, and correlation among variables, the general processing model cannot be applied well, but the structural equation model can solve these problems well.

2.2. Indicator specification

SEM structural equation model includes two parts: measurement model and structure model. The corresponding expression of the SEM structural equation model is shown in **Table 1**.

Table 1. Corresponding expression of SEM

Model	Equation	Expression
Measurement model	Measurement equation	$X = \Lambda_x \xi + \delta$ $Y = \Lambda_y \eta + \varepsilon$
Structural model	Structural equation	$\eta = B\eta + \Gamma\xi + \zeta$

The meanings of symbols in SEM expressions are shown in **Table 2**.

Table 2. Meaning of symbols of SEM

Symbol	Meaning	Symbol	Meaning
X	A vector composed of exogenous observed variables	δ	The error term of the exogenous observed variable
Y	A vector of endogenous observed variables		A vector of endogenous latent variables
B	Relationships between potential variables		Residual term of endogenous observed variable
	The relationship between exogenous observed variables and exogenous latent variables		Path coefficient, the influence of exogenous latent variables on endogenous latent variables
	The relationship between endogenous observed variables and endogenous latent variables		The unexplained part of a structural equation - the residual term
	A vector set of exogenous latent variables		

3. Influencing factors of operation fatigue in manufacturing enterprises

3.1. To determine the influencing factors of work fatigue of online workers in manufacturing enterprises

Work fatigue is never caused by a single factor, and there are many influencing factors, but it is roughly concentrated in the four main aspects of “people, things, rings, and pipes”, which can be summarized as internal factors and external factors. The internal factors are the situation of the operators themselves, and the external factors mainly include the nature of the operations, the operating environment, the operating equipment, and the enterprise management. These two factors are not independent of each other, and it is usually the interaction between them that leads to the production of work fatigue. Based on previous studies on factors affecting job fatigue by scholars, combined with the actual operation characteristics of manufacturing enterprises, 22 influencing factors were finally selected from five aspects: operator, operation itself, operation environment, operation equipment, and enterprise management.

3.2. Preparation of questionnaire and collection

According to the 22 influencing factors identified, a five-level Likert scoring method was used to compile a questionnaire, and each employee scored the influencing factors of job fatigue according to their actual situation. The questionnaire consists of two parts, the first part is the basic information of the respondents, including gender, age, monthly salary, etc. The second part is the influence factors of online workers' fatigue in 22 selected manufacturing enterprises, and the impact degree according to the subjective feelings of the respondents. The questionnaire distinguishes the impact degree as great, large, general, little, or even basically no impact, and according to 5 points, 4 points... 1 point to score. A random sampling method was adopted to select 210 employees from three local manufacturing enterprises for a questionnaire survey. 210 questionnaires were issued, 208 questionnaires were recovered, and 205 valid questionnaires were obtained after eliminating invalid questionnaires.

3.3. Sample data analysis

In this study, the main data were collected in the form of a scale, and the next analysis could only be carried out after the validity of the data obtained from the questionnaire had been tested.

Cronbach's α is often used to check the validity of data, In the 0–1 range, the greater the alpha value, the higher the internal consistency of the data. In this paper, the reliability test results obtained by SPSS 26.0 software are shown in **Table 3**. It can be seen that the reliability coefficients of each influencing factor are within the range of 0.8–1. Therefore, the reliability of the data used in this study meets the requirements and can be analyzed in the next step.

Table 3. Impact factor reliability analysis

Variable	Cronbach's α	Number of terms
Operator	0.818	4
Job	0.853	5
Environment	0.831	4
Equipment	0.839	4
Enterprise management	0.857	5
Factor of influence	0.963	22

4. SEM empirical analysis and evaluation

4.1. SEM construct

To facilitate the construction of the model, each observed variable and potential variable are represented by a letter. The variables represented by each letter are shown in **Table 4**.

Table 4. The letters represent the variables in the table

Latent variable	Alphabetic representation	Observed variable	Alphabetic representation	Latent variable	Alphabetic representation	Observed variable	Alphabetic representation
Operator	D	Physical condition	D1	Environment	B	Temperature and humidity	B3
		Working pressure	D2			Noise	B4
		Job skills	D3	Equipment	F	Reliability of equipment	F1
		Job satisfaction	D4			Operability of equipment	F2
Job	O	Operation time	O1			Coordination of equipment	F3
		Operating speed	O2			Update frequency of equipment	F4
		Job intensity	O3	Enterprise management	M	Reward and punishment system	M1
		Task difficulty	O4			Salary and welfare	M2
		Job accuracy	O5			Extra shift system	M3
Environment	B	Lighting condition	B1			Position arrangement	M4
		Dust	B2			Interpersonal relationship	M5

In this paper, AMOS 24.0 software will be used to build the structural equation model. Five variables such as the operator, the operation itself, operation environment, operation equipment, and enterprise management will be taken as five potential variables, and 22 variables such as physical condition, operation time, lighting conditions, and reliability of machinery and equipment will be taken as observed variables. e1, e2, e3... e22 is the error term of each observed variable, and all path coefficients are set to 1 by default, so the resulting model is shown in **Figure 1**.

4.2. SEM parameter estimation and fitting

After the construction of the SEM model, it is necessary to carry out a fitting evaluation. The next step can only be carried out after it is determined that the model is fully compatible with the data. After fitting, the SEM model is shown in **Figure 2**.

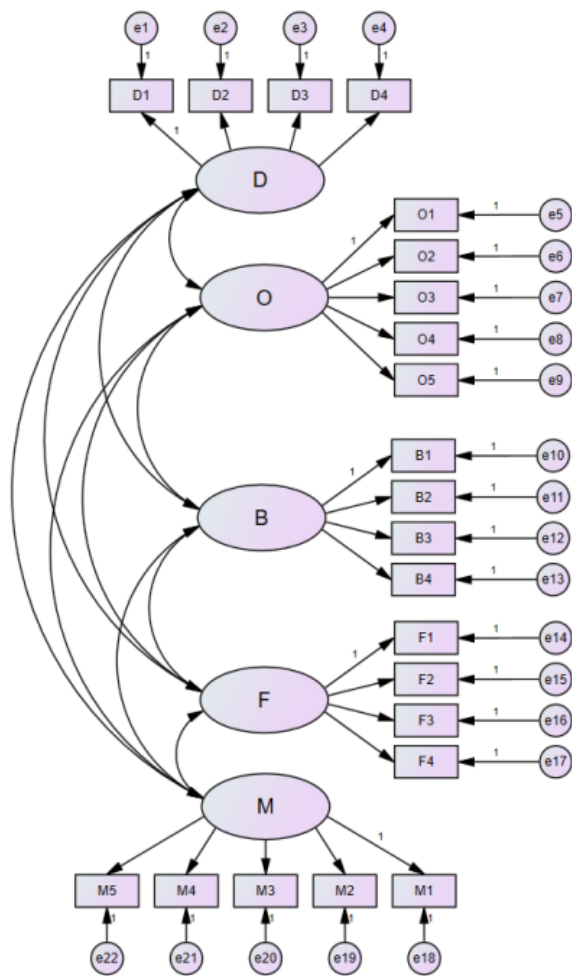


Figure 1. SEM model of influencing factors of job fatigue

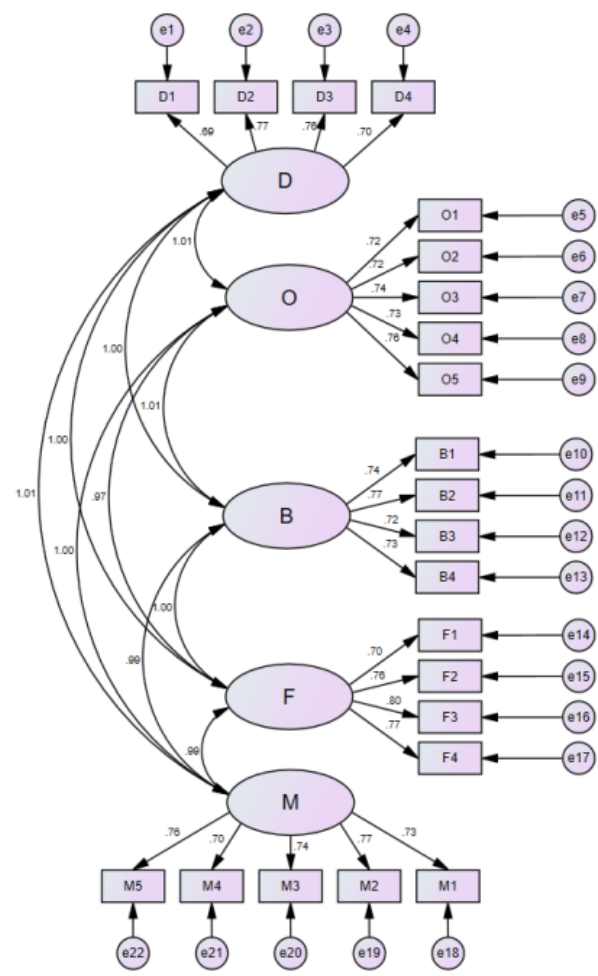


Figure 2. The SEM model was fitted

After fitting the model, its fit degree should be tested. Considering the stability of the fit degree evaluation indexes, this paper selected CMIN/DF, RMSEA, IFI, TLI, and CFI to evaluate the goodness of fit of the model. The test results of model fitness after fitting are shown in **Table 5**.

Table 5. Model fit test

Index	Reference standard	Measured result
CMIN/DF	1–3 is excellent, 3–5 is good	1.13
RMSEA	<0.05 is excellent, <0.08 is good	0.025
IFI	>0.9 is excellent, >0.8 is good	0.991
TLI	>0.9 is excellent, >0.8 is good	0.99
CFI	>0.9 is excellent, >0.8 is good	0.991

According to the model adaptation test results in **Table 5**, CMIN/DF=1.13 and RMSEA=0.025 are both representative indicators in the excellent range. In addition, the test results of IFI, TLI, and CFI were all above 0.9. These results indicate that the fitted structural equation model is a good fit and can be used for further analysis.

4.3. SEM confirmatory factor analysis

4.3.1. Scale convergence validity and combination reliability test

Under the premise that the SEM model has a good fit, the convergence validity (AVE) and combination reliability (CR) of each dimension of the scale need to be further tested. Only when $AVE \geq 0.5$ and $CR \geq 0.7$ can it be shown that the fitted model has good convergence validity and combination reliability, and the fitting results are authentic. The specific results are shown in **Table 6**.

Table 6. Convergence validity and combination reliability test for each dimension

First-order factor	Second-order factor	Factor loading	AVE	CR	First-order factor	Second-order factor	Factor loading	AVE	CR
D	D1	0.689	0.531	0.818	F	F1	0.696	0.573	0.842
	D2	0.767				F2	0.763		
	D3	0.758				F3	0.798		
	D4	0.696				F4	0.766		
O	O1	0.716	0.538	0.854	M	M1	0.732	0.547	0.858
	O2	0.725				M2	0.767		
	O3	0.742				M3	0.739		
	O4	0.727				M4	0.703		
	O5	0.76				M5	0.756		
B	B1	0.741	0.551	0.831					
	B2	0.772							
	B3	0.723							
	B4	0.733							

According to the analysis results in **Table 6**, it can be seen that in the validity test of the scale after fitting, the AVE value of each impact factor is above 0.5, and the CR value is above 0.7, which indicates that each impact factor has good convergence validity and combination reliability, and the scale is reasonably formulated.

4.3.2. The scale describes statistics and normality tests

Before using fitted model output results, descriptive statistical analysis and normality tests should be carried out for each influencing factor used in this study to verify whether the data of each measurement item meets the approximately normal distribution. If not, the reliability of the model output results will be reduced. Specific test results are shown in **Table 7**.