CONTENTS

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Vocational Education and Sustainable Development: Exploration of the application of ESG Framework in Vocational Curriculum Design

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Abstract: Driven by the Global Sustainable Development Goals, vocational education faces an urgent need to integrate into the environmental, Society and Governance (ESG) framework. This paper discusses the practical application of ESG concept in vocational curriculum design, from curriculum goal setting, teaching content development to evaluation system construction, and puts forward the innovative path of integrating the concept of sustainable development into vocational education. Research shows that by strengthening the cultivation of environmental awareness, social responsibility and governance ability in curriculum design, vocational education can not only improve the comprehensive quality of students, but also promote the strategic role transformation of vocational colleges in sustainable development. This paper provides theoretical support and practical guidance for educational policy makers and vocational education institutions.

Keywords: vocational education; sustainable development; ESG framework; curriculum design; and environmental awareness

1 Introduction

1.1 Research background and significance

At present, the world is facing multiple challenges such as climate change, resource depletion and social inequality. Promoting sustainable development has become the consensus of all governments and all sectors of society (United Nations, 2020). As an important way to train technical talents, the goal of vocational education is not only to meet the needs of the industry, but also to play a key role in cultivating social responsibility and awareness of sustainable development (UNESCO, 2017). The ESG (Environment, Society and Governance) framework provides an innovative theoretical perspective and practical path for vocational education, which can help educational institutions to integrate the concept of sustainable development in curriculum design and implementation, so as to cultivate comprehensive talents with both professional ability and sustainable development literacy (World Economic Forum, 2021).

1.2 The relationship between vocational education and sustainable development

Vocational education plays a vital role in sustainable development, which is reflected in cultivating green skills, promoting social equity and promoting economic transformation. First of all, vocational education by adjusting the teaching content, the green technology, environmental management is closely related to sustainable development skills into the curriculum system, cultivate students environmental awareness and green skills, in meet the green economy demand for professional talents at the same time, help students better adapt to the development trend of the future low carbon economy (UNESCO, 2012). Secondly, vocational education plays an important role in promoting social equity. By providing equal educational opportunities, vocational education provides learning and employment opportunities for more groups, especially the socially disadvantaged groups, reduces social differentiation and enhances the level of inclusive development. This fair education model not only improves the individual quality of their life, but also promotes social harmony and stability, laying the foundation for the realization of broader social progress (UNESCO, 2021). In addition, vocational education is an important bridge to promote the green transformation of the economy. At present, the world is changing from the traditional high-energy consumption model to a low-carbon economy model. Vocational education helps enterprises adapt to the emerging environmental requirements and market changes by cultivating the talents needed for the green economy. This mode of coordinated development of education and economy, Not only accelerated the rise of green industries, but also promoted the optimization of economic structure and the realization of sustainable development goals (Fang Yu et al., 2023).

1.3 Applicability of the ESG framework in vocational education

ESG is short for Environmental, Social, and Governance, which originated in the corporate space and aims to measure an organization's environmental protection, social responsibility, and governance performance. However, this framework also applies to the field of vocational education, providing a completely new perspective for vocational education curriculum design. The specific manifestations are:

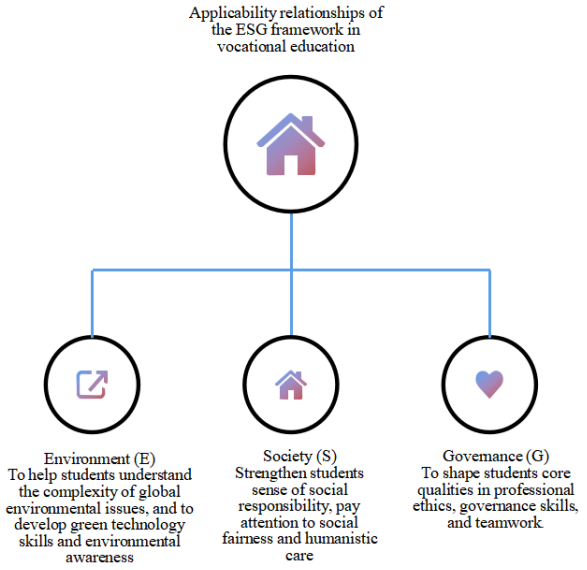

Figure 1: The applicability relationship of the ESG framework in vocational education

Environment (E): Help students to fully understand the complexity of global environmental issues, including key issues such as climate change, biodiversity reduction, energy crisis, and pollution control (UNESCO, 2017). Students should not only master relevant scientific knowledge and policy frameworks, but also be familiar with the development and application of green technologies, such as renewable energy technology, low-carbon manufacturing technology and intelligent environmental protection solutions (World Economic Forum, 2021). At the same time, schools should actively cultivate students' awareness of environmental protection, encourage them to practice the concept of sustainable development in their daily life, and integrate environmental protection into all aspects of study, work and life, so as to become the future leaders in promoting green transformation (UNEP, 2020).

Society (S): Pay attention to enhance students' sense of social responsibility, so that they can pay attention to their personal development, but also actively participate in the cause of social equity and humanistic care (UNESCO, 2018). Education should guide students to pay attention to social issues such as vulnerable groups, social inequality, public health and cultural diversity, and cultivate their sense of responsibility to serve and improve the society. In addition, schools can enhance students practical ability and empathy through voluntary service, social practice projects and case teaching, so as to promote them to become responsible and warm social citizens and contribute to the building of a more equitable and inclusive society (OECD, 2019).

Governance (G): Dedicated to shaping students core qualities in professional ethics, governance skills and teamwork, to help them adapt to the needs of modern workplace and social organizations (World Economic Forum, 2021). In terms of professional ethics, education should focus on cultivating students sense of integrity, the spirit of the rule of law, and respect for multiculturalism (UNESCO, 2017). In terms of governance ability, schools need to strengthen students learning and practice in the areas of organizational management, problem solving and decision making, and improve their ability to manage complex affairs at different levels. At the same time, it pays attention to the cultivation of teamwork skills. Through project cooperation, simulation practice and communication training, we can help students learn to cooperate efficiently and stimulate innovative thinking, so that they can be qualified for the leadership role and collaborator status in the team in their future career (OECD, 2020).

By embedding the ESG concept into vocational education curriculum design, students can not only improve their professional ability, but also enhance their understanding and practical ability of sustainable development, enabling their future career development.

2 Analysis of the sustainable development and the current situation at home and abroad

2.1 The convergence between sustainable development goals (SDGs) and vocational education

The Sustainable Development Goals (SDGs) proposed by the United Nations point out the direction for global social, economic and environmental development. In particular, goal 4 "Ensure inclusive and equitable quality education" and goal 13 "Action on Climate Change", which are highly compatible with vocational education (United Nations, 2015). As a key way to train technical and skilled personnel, vocational education plays an irreplaceable role in tackling climate change, promoting economic transformation and achieving social equity (UNESCO, 2017). The integration of SDGs into the vocational education curriculum can provide students with the dual value of skills and sustainability, enabling them to not only meet market needs, but also actively participate in global sustainability initiatives (UNEP, 2020).

2.2 Analysis of vocational education curriculum design at home and abroad

In recent years, domestic vocational education has made remarkable progress in the promotion of policies, but there are still problems such as the disconnection between curriculum content and industrial demand, and the insufficient coverage of sustainable development education (Ministry of Education of China, 2021). Curriculum design pays more attention to skills training, but is relatively weak in the systematic cultivation of environmental protection, social responsibility and governance ability. In contrast, some foreign developed countries, such as Germany, the "dual system" education model, closely combines vocational education with the actual needs of enterprises, and pays attention to the cultivation of students in social responsibility and environmental awareness (OECD, 2020). Through comparative analysis of the current situation at home and abroad, it can provide reference for improving the vocational education curriculum system and explore how to better integrate the ESG framework into the vocational education curriculum.

3 Case analysis

3.1 A typical case of ESG practice in domestic vocational education: a green skills course of a college in Jiangsu Province

A college in Jiangsu province takes environmental sustainable

development as its core goal, actively explores the innovative model of combining vocational education with green industry, and integrates the concept of sustainable development into the design and implementation of vocational courses. The university has set up a professional curriculum system for green manufacturing, clean energy, ecological agriculture and other fields, and developed forward-looking teaching resources according to the industrial needs, so as to cultivate technical talents who meet the requirements of green economic development. In terms of curriculum design, the college adheres to the concept of "integration of industry and education, school-enterprise cooperation", and has established close cooperative relations with local governments and related enterprises. The local government provides policy support and industry guidance for course development to ensure that the course content matches the regional economic development strategy; the enterprise provides technical equipment case resources and training base to create real career scenarios for students. Through this cooperation mode, students can be exposed to cutting-edge green technology application scenarios in the learning process, including the installation and maintenance of clean energy equipment, and the planning and implementation of green agriculture projects, which greatly improves students' ability to understand and apply professional knowledge.

Results: It has trained a group of technical talents to meet the needs of green economy. The employment rate of course graduates in the new energy industry reaches more than 80%.

3.2 Typical case of ESG practice in foreign vocational education: dual system education and sustainable development in the German vocational education system

Germany's dual vocational education system is famous for its unique joint training mode of enterprises and schools, which provides strong support for the combination of vocational education and the concept of sustainable development through the high integration of theory and practice. In this system, students, on the one hand, receive systematic theoretical education in schools, and on the other hand, conduct practical operation in enterprises, so as to comprehensively improve their professional ability and practical application ability. In recent years, Germany has further integrated the concept of environment, society and governance (ESG) into the dual vocational education system, laying a foundation for cultivating inter-disciplinary talents with both sustainable development consciousness and vocational ability. In terms of technical education, the German vocational education system pays attention to the concept of energy conservation and environmental protection throughout the curriculum design. For example, in the vocational education of the machinery manufacturing industry, the course content covers the design and optimization of energy-saving and environmental protection equipment, and the technology development of the efficient utilization of resources. While learning traditional mechanical manufacturing skills, students master how to use new technologies to reduce resource consumption and environmental pollution. The enterprise practice link provides students with a wide range of application opportunities, such as participating in the research and development, installation and debugging of green equipment in actual projects. Through this learning path, students can not only master the advanced industrial technology, but also have a deep understanding of its sustainable development application price in the exhibition

Results: Students have a deeper understanding of sustainable development. The development of the green industry in Germany has benefited from the transfer of such vocational education talents.

3.3 Comparison of successful experiences and shortcomings

Table 1: ESG comparison table in domestic and foreign vocational education

Dimension	Domestic practice	Foreign practice
Environment(E)	Focus on the course design of green technology and ecological agriculture; many practical links, but insufficient technical depth.	Emphasize the combination of technology research and development and practice; green skills are highly compatible with the industrial system.
Society(S)	Focusing on local social issues and increasing employment rate through school-enterprise cooperation, but cultivation of social responsibility.	Focus on the cultivation of social responsibility in professional ethics and teamwork courses.
Administer(G)	Schools lead the curriculum development, the enterprise participation is limited, and the governance mechanism is relatively single.	Enterprises are deeply involved in curriculum development, and the school and the enterprise governance mechanism are highly coordinated.
Overall advantage	Talent training meets the needs of local industries and has a strong employment orientation.	Theory and practice are closely combined, and they pay attention to the global vision and sustainable development.
Overall lack of	The concept of sustainable development is not permeated enough, and the course content needs to be deepened.	The course is more difficult and has relatively high requirements for the students.

The practice of domestic and foreign vocational education under the ESG framework provides valuable experience for promoting sustainable development. Domestic education focuses on the combination with the local economy, while foreign education has more advantages in the integration of ideas and system improvement. In the future, vocational education can play a greater role in sustainable development by strengthening international exchanges and cooperation and integrating successful experiences both at home and abroad.

4 ESG framework embedded in career course strategy analysis

4.1 Assessment of the impact of the ESG framework on vocational curriculum design

Research shows that the integration of the ESG framework into vocational curriculum design has profound effects on curriculum content, teaching model and student development goals.

First of all, the adjustment of curriculum content makes education put more emphasis on the integration of environment, society and governance. Students not only need to master traditional professional skills, but also understand how to apply the concept of green technology, social responsibility and effective governance in practice.

Table 2: Assessment table of the impact of the ESG framework on vocational curriculum design

Domain	Change the content
Multi-dimensional expansion of the course content	The ESG framework guides the expansion of vocational courses from pure technical skills training to multiple fields, including environmental protection, social responsibility and professional ethics. The course content is more diversified and comprehensive, providing students with a more comprehensive learning experience.
Innovation of teaching mode	Driven by the ESG concept, more attention is paid to the combination of practice and theory in curriculum design, especially through real case analysis, interdisciplinary cooperation and simulation practice projects, to enhance students ability to solve practical problems.
Upgrading of students training objectives	Through the introduction of the ESG framework, students need not only to master professional skills, but also to develop a global vision and awareness of sustainable development to lay a broader foundation for future career development.

4.2 Education quality and employ ability improvement after integration into ESG

With the integration into the curriculum design of vocational education, the quality of education and students employ ability have been significantly improved. The introduction of ESG has not only improved the depth and breadth of the course content, but also promoted the education system to pay more attention to the cultivation of students comprehensive quality, including the ability of green technology, social responsibility and professional ethics. Through the multi-dimensional teaching mode and practical links, the students professional skills have been strengthened, and they also show a stronger competitiveness in dealing with practical problems and adapting to the needs of the workplace. The next section will further explore how the ESG framework can specifically improve the quality of education and provide a broader growth space for students employ ability.

Improvement in education quality: It have found that the introduction of ESG framework has significantly improved the overall quality of vocational education. In the learning process, students pay more attention to the analysis and solution of practical problems, especially in terms of green technology, social inclusiveness and governance ability. Through the participation of real cases and practical projects, students learning results are more close to the real needs, and the theoretical knowledge is more solid.

Enhancing employ ability: The ESG curriculum is close to the needs of green economy, social innovation and modern corporate governance. ESG-educated students show greater competitiveness in the job market, especially in emerging industries such as new energy, green manufacturing, and sustainable agriculture. Data show that the employment rate of course graduates integrated with ESG concept is generally higher than that of traditional vocational education students, and they show stronger adaptability and innovative spirit in the workplace.

4.3 Strategies for the continuous improvement of vocational education

In order to further optimize the integration of vocational education and sustainable development, a series of strategies can be adopted. First of all, deepen the integration of industry and education, promote the cooperation between vocational education institutions, enterprises and those of the government, and ensure the synchronous update of educational content and industrial demand through joint curriculum development and resource sharing. Secondly, improve the curriculum system, dynamically adjust the curriculum according to the industry trend and social needs, especially strengthen the teaching depth of green technology and professional ethics, to improve the comprehensive quality of students. Strengthening the practice link is also the key. By increasing the practice projects and case teaching related to ESG, students can provide them with more opportunities to apply skills in real scenarios and improve their ability to solve practical problems. In addition, to improve the level of teachers, through training and international exchanges, to help teachers to master the ESG concept and its application methods, to build a high-quality teaching team. Finally, a scientific evaluation mechanism should be established to regularly monitor course effects and student development to provide data support for continuous improvement. By implementing these strategies, vocational education will play a greater role in cultivating talents with both technical ability and sustainable development literacy, and provide stronger support for the sustainable development of society and economy.

5 Conclusion and suggestion

5.1 Conclusion

This study discusses the application of ESG framework in the design of the quality of education and sustainable development ability, found that the ESG framework course pay more attention to environmental protection, social responsibility and corporate governance, comprehensive technical skills and sustainable development concept, effectively improve the students knowledge depth, comprehensive ability and employment competitiveness, especially in the field of green economy and emerging industries. However, the construction of teacher training, policy support and evaluation system still needs to be further improved to fully realize the potential of the ESG framework in vocational education.

5.2 Proposals of the policy makers

It is suggested that the application of the ESG framework in vocational education should be comprehensively promoted by improving policy support, promoting the integration of industry and education, and establishing an evaluation mechanism. Specifically, it includes the introduction of incentive policies such as curriculum development funding, special funds for green skills training and incentive mechanisms;; formulating measures to promote school-enterprise cooperation, such as tax incentives and cooperative project funding, to enhance the depth of production and education integration; building a scientific evaluation system and integrating

the implementation effect of ESG concept into the assessment to ensure the effective implementation and continuous optimization of policies.

5.3 Future research direction

Future research should focus on the construction of a multi-dimensional evaluation framework, industry customization research, international comparative analysis, and the combination of technology and education. Specifically, it includes the development of evaluation tools covering environment, society and governance, comprehensively monitoring the implementation effect of ESG framework in vocational education; exploring the needs of industries for green skills and social responsibility in different industries, and designing more targeted courses; comparing the successful practices in the integration of vocational education and sustainable development, and refining the experience applicable to local; studying the application potential of intelligent technology and online education in ESG framework to promote the innovation and optimization of vocational education.

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Enhancing the Management of International Chinese Language Education in Southeast Asia

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Abstract: In the new era, management has become the "fourth key element" in international Chinese language education, alongside teachers, textbooks, and pedagogy. Southeast Asia, a key region for Chinese education, is vital for the Belt and Road Initiative and regional cooperation. As demand for Chinese grows, improving educational management is crucial. This paper explores enhancing management capacity through three perspectives: promoting Chinese civilization, advancing governance modernization, and supporting high-quality educational development. It also suggests strengthening research, improving talent cultivation, and building sustainable management systems to contribute to global Chinese education governance.

Keywords: Guangzhou area; birth rate; PEST analysis method

1 The Strategic Significance of International Chinese Language Education Management

As global politics, diplomacy, and historical patterns rapidly evolve, international Chinese language education faces both new opportunities and significant challenges. A key question emerges: how can the field balance domestic and international priorities and bridge the East–West divide to achieve sustainable, high-quality development?

Since the founding of the People's Republic of China, international Chinese education has grown steadily for over seventy years. It now serves as a key platform for educational openness, cultural exchange, and global mutual understanding. As more countries incorporate Chinese into national curricula and learner numbers grow, new complexities have emerged—ranging from diverse educational needs to institutional and policy challenges.

While teacher training, textbooks, and pedagogy—the traditional "three pillars" — have long supported the field, they are increasingly inadequate in regions like Southeast Asia. Here, issues such as teacher shortages, uneven resource distribution, and outdated management models are acute.

Recent studies highlight education management as a crucial but overlooked "fourth pillar." Gaps in planning, coordination, and leadership hinder reform and sustainability. Despite rising academic interest, research in this area remains limited.

This paper examines the strategic role of education management through four dimensions: strengthening China's international communication, modernizing governance, improving educational quality, and enhancing management systems—laying a foundation for future global development.

2 Boosting the Influence of Chinese Civilization Through the Capacity Building of International Chinese Education Management

Compared with traditional competitions based on hard power, cultural soft power has increasingly become a key variable in expanding a country's international influence and shaping its national image. As a carrier of culture and a pioneer of its dissemination, language plays a fundamental role in the construction of soft power. Chinese is not merely a tool for communication, but also an important medium for conveying Chinese culture and values. As a crucial component of China's national language strategy, international Chinese language education serves as a vital bridge for promoting Chinese civilization on the global stage.

In some Southeast Asian countries, there is a noticeable tendency to prioritize expansion over governance, quantity over quality, and teaching over management. While Chinese language programs continue to grow in number, the lack of effective governance mechanisms, weak organizational coordination, and underdeveloped support systems have seriously undermined the quality of instruction and limited the depth of Chinese cultural dissemination. Clearly, the absence of strong governance capacity has become a bottleneck restricting both the quality and sustainability of Chinese language education in the region.

3 Strengthening the management capacity of international Chinese language education in Southeast Asia is an integral part of advancing the Belt and Road Initiative

Strengthening international Chinese language education management in Southeast Asia is essential to advancing the Belt

and Road Initiative (BRI). As a strategic hub with deep historical ties, cultural diversity, and close cooperation with China, Southeast Asia plays a pivotal role. Effective language education governance supports mutual understanding, educational collaboration, and cultural exchange.

Despite growing enthusiasm and rapid expansion, Southeast Asia faces significant management challenges, including fragmented institutions, slow policy responses, and inadequate localization. These issues hinder sustainable progress in China-ASEAN educational cooperation, limiting the strategic role of language education. A systematic governance approach, integrating policy design and grassroots implementation, is crucial for fully realizing the benefits of Chinese education within the BRI framework.

Therefore, the enhancement of international Chinese education management capacity in Southeast Asia should be integrated into the broader "soft connectivity" agenda of the Belt and Road Initiative. By aligning educational policies, coordinating teacher management, and establishing standardized evaluation frameworks, it is possible to construct a multilateral, collaborative, and mutually beneficial governance model. Such efforts will not only address current structural issues in Chinese language education, but also provide strong support for building cultural identity and strategic trust between China and Southeast Asian countries—ultimately reinforcing the social foundation of people-to-people connectivity under the BRI framework.

4 Enhancing governance in Southeast Asia's international Chinese education sector plays a vital role in advancing the overall quality of international Chinese language education

Enhancing the governance capacity of international Chinese education in Southeast Asia plays a vital role in advancing the overall quality of global Chinese language education. As a strategic corridor linking China with the rest of the world, Southeast Asia functions not only as a regional hub for linguistic and cultural exchange but also as a powerful force in the global dissemination of Chinese education and the promotion of civilizational dialogue. The region maintains deep-rooted connections with China in various fields such as culture, economy, and education, having developed a solid foundation for Chinese language learning and long-standing cooperation. With its advantageous geographic location and its unique dual characteristics as part of the East Asian cultural sphere and a multilingual environment, the effectiveness of governance in Southeast Asia has significant implications for surrounding countries and for multilingual education strategies across diverse linguistic settings.

5 Strategies for Strengthening Governance in International Chinese Education

Language education management plays a critical role in the global dissemination of languages. However, scholarly discussions surrounding the construction of systematic frameworks for language education management remain insufficient, particularly in the context of international Chinese language education governance, where research is still in its early stages. Existing studies primarily focus on two areas: the management of international students in China and classroom management in Chinese language education.

The second major research focus lies in classroom management within international Chinese education. As a fundamental factor influencing teaching efficiency and learning outcomes, classroom management is particularly complex in multilingual and multicultural settings, where student backgrounds are diverse and learning environments are varied. Although the volume of research has grown in recent years, the field still suffers from a lack of theoretical innovation, repetitive themes, and uneven academic quality. Much of the existing literature consists of master's theses in Teaching Chinese to Speakers of Other Languages (TCSOL), with a limited number of high-quality journal publications. While some scholars have begun exploring broader areas such as instructional management, volunteer teacher coordination, and internship administration, these studies remain fragmented and lack systematic depth.

6 Conclusion

In conclusion, enhancing the governance capacity of international Chinese language education is not only a practical requirement for achieving high-quality development but also a strategic foundation for strengthening the global communication of Chinese civilization and advancing China's cultural soft power. Particularly in key regions such as Southeast Asia, the construction of an efficient, professional, and sustainable educational governance system has become a critical pathway for addressing complex educational environments and meeting the diverse needs of learners. Moving forward, it is essential to deepen both theoretical research and practical exploration, prioritize the cultivation of management professionals, and promote institutional innovation. Through these efforts, the management system of international Chinese education can evolve toward greater scientific rigor, standardization, and systemic integration, providing strong support for the global advancement of Chinese language education.

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Gender and Power Relations in Don Quixote: A Feminist Analysis of the Female Characters

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Abstract:This paper analyzes the female characters in Don Quixote from a feminist perspective, exploring the ways in which gender and power relations are presented in the novel. By analyzing the major female characters in the novel (Dulcinea, Teresa Panza, Marcella, and other female characters), the paper points out that these characters, though seemingly weak or subordinate on the surface, actually reveal the gender inequality in the society of the time and how women find their place in the social structure. The paper uses the literature review method to summarize relevant studies, analyze the relationship between gender and power in Don Quixote, and reveal how Cervantes reflects the hierarchical system of the Spanish society of the time through female characters.

Keywords: Don Quixote; Cervantes; Feminism; Gender and Power; Female Roles

1 Introduction

1.1 Background of the Study

Don Quixote is one of the classics of Spanish literature, in which Cervantes describes a series of adventures of the protagonist, Don Quixote, and his squire, Sancho Panza, revealing the conflict between human ideals and reality. Although Don Quixote mainly exposes the perception and growth of the male protagonist, the female characters in it play an important role in shaping male identity, demonstrating gender inequality, and reflecting the gender norms of the society at that time, and the female characters in the novel also provoke a profound social critique within the framework of gender and power relations.

Early criticisms focused mostly on the novel's narrative techniques, character psychology or the satirical significance of chivalric literature. In recent years, scholars have gradually focused on gender issues in the novel and its satire of patriarchal society (Hernández-Pecoraro, 2002).

1.2 Literature review

Although women are not the main characters in this novel, they play a crucial role in advancing the plot, characterization and revealing social phenomena. The words and actions of the female characters, their social status, and their interactions with the male characters in the novel reflect the gender concepts and the power structure of the patriarchal system in the 17th century Spanish society. In particular, female characters such as Dulcinea, Teresa Panza, and Marcela not only portray social identities that are different from those of male characters, but also challenge gender norms in the patriarchal system (Hernández-Pecoraro,2002).To some extent, these characters reflect Cervantes' critique of gender inequality in 17th century Spanish society, and also show the multiple identities and complexities of women in a patriarchal culture. Their complexity, independence and sense of resistance shown in the novel give Don Quixote a gender consciousness that transcends its time.

In the 17th century Spanish society, religious beliefs, aristocratic culture, and feudalism together shaped a male-centered social structure (Lewis & Sánchez, 1999). Women's roles in society were governed by the three core values of chastity, obedience, and motherhood, and women's marriages, property, and social status were often determined by their fathers, brothers, or husbands (Cornell,2013). The profound influence of such gender concepts is evident in literary creations, where female characters are often portrayed as idealized lovers, victims, or moral degenerates. However, Cervantes skillfully breaks through this stereotype in his creation of Don Quixote by giving more subjectivity and complexity to female characters. It is in this social context that the multifaceted nature of female characters, power struggles, and issues of gender representation in Don Quixote have become key topics in exploring the work.

Many scholars regard Dulcinea as the most symbolic female character in Don Quixote. Lu points out that Dulcinea is not a real woman, but an idealized vision of Don Quixote, representing the projection of male fantasies about women (Lu, 2024). Similarly, Jin emphasizes that the illusory image of Dulcinea reveals how male-dominated narratives construct an idealized image of the "perfect woman," thus avoiding the real subjectivity of women (Jin, 2021). In Cervantes, Marcella is considered one of the characters with the greatest sense of female independence, and Shen argues that Marcella's active rejection of marriage and her insistence on self-independent choices exemplify a challenge to traditional gender roles (Shen, 2014). Chu and Li point out that Marcela's declaration ("I was born free") has a strong rebellious meaning in the literary context of the 17th century, embodying the challenge of female subjectivity (Chu & Li, 2008). The image of Teresa Panza has also received much attention in studies on female characters. Triplette suggests that Teresa Panza, as a woman of the common class, demonstrates her hidden power in a male-dominated discursive environment through her husband's worship and following Don Quixote (Triplette, 2018). Mancing emphasizes that although Teresa Panza has no social status, her power is still represented in traditional patriarchal concepts (Mancing, 2006). In terms of the gender performance of female characters, Alliston argues that some of the other female characters in Don Quixote protect their own interests by deliberately assuming gender roles that conform

to societal expectations, and that this group of people mainly refers to roles such as prostitutes and poor women. And that this strategy of "gender performance" is exactly an early example of Butler's theory of "gender performance" in literary practice (Alliston, 2011).

Regarding Cervantes' view of women, Xu points out that although Cervantes reinforces the gender stereotypes of the traditional patriarchal society to a certain extent, he also demonstrates a gender consciousness that transcends the times by portraying female characters who are independent, intelligent and courageous (Xu,2024). Hernández emphasizes that Cervantes' image of women is "both contradictory and similar", and that he tries to find a balance between controversy and reality, revealing the dilemma of women's equilibrium in society ((Hernández-Pecoraro, 2002).

All these views reveal that the female characters in Don Quixote are not single "dependents" or "victims", but individuals with complexity and subjective consciousness. On the basis of these studies, this paper will further explore how these female characters embody their subjectivity in the tension between gender and power, and analyze the uniqueness of Cervantes' portrayal of women.

1.3 Theoretical and Conceptual Framework

The following theoretical framework and conceptual tools were used in this study as a theoretical underpinning to analyze the relationship between gender and power in Don Quixote.

1.3.1 Gender and Power Theory (GPT)

The theory of "gender and power" focuses on how gender is structured in society in relation to power structures, affecting the social status, distribution of resources and identity of individuals and groups.

Cornell proposed the Gender and Power Theory (GPT), which focuses on how society shapes gender differences through power relations, emphasizing the role of power structures, production relations, and affective relations in the gender system(Cornell,2013). Cornell argues that gender is not merely a distinction of physical characteristics, but a social construct, and that men and women are treated differently in society due to differences in power structures. Cornell also developed the concept of Hegemonic Masculinity, which contributes to the theory of gender and power, which argues that men dominate important relational dominance in social power structures and that this dominance is dependent on the perception of the "ideal masculinity" is continuously shaped and maintained. Cornell points out that the maintenance of this hegemonic masculinity is not only dependent on male control over women, but also involves dominance and submission between different groups of men.

In Don Quixote, male characters (e.g., Don Quixote and Sancho) express their positions of power through chivalric adventures, fantasizing about women, or exerting influence; in contrast, female characters are often in a position of being gazed at, judged, or manipulated. By analyzing how female characters accept, challenge, or reshape this gendered power structure, a critical sense of latent patriarchal power can be revealed in the novel. For example, Marcela's declaration of independence and rejection of marriage is a direct challenge to the social power structure of power.

1.3.2 Feminist Theory (FT)

Feminist Theory (FT) is a critical theory that seeks to expose and critique gender inequalities and how power affects women's status and experiences. The theory not only focuses on women's rights and status in society and advocates for social change to promote gender equality, but also addresses broader issues of gender, power, identity, and culture. In Don Quixote, Dulcinea (Dulcinea) does not exist in reality, but is a female figure in Don Quixote's fantasy, embodying the idealization and objectification of women for men. "The Widow's Tale reflects the gender power relations of 17th century Spanish society, where Camila is placed in a male-controlled environment, trapped in the power structure of marriage, and restricted by social norms from freely choosing her own destiny. Its fate can be analyzed through liberal feminism or radical feminism. Other liberal feminists believe that marriage should not be a tool to control women but should be based on equality and trust. However, Camilla's marriage is a power relationship in which her fidelity is objectified as a wager of friendship between men, and Anacelmo's actions reflect the patriarchal society's suspicion of women's fidelity, which not only undermines the marriage relationship, but also restricts women's personal development. Camilla's ending tragically demonstrates the fragile position of women in society as she is pushed into a cycle of being manipulated, tested, and ultimately blamed.

1.4 Significance of the Study

By combining gender and power theory, feminist theory, and related concepts, this study analyzes in depth the complexity of female characters in Don Quixote, dissects how female characters struggle to survive in a patriarchal society and seek subjectivity in the face of gender oppression, reveals the novel's profound critique of gender power relations, and provides new perspectives for understanding gender politics in literature.

This study is important at both theoretical and practical levels.

1.4.1 Theoretical Significance

a.This study cuts through the feminist perspective to further enrich the interpretation of Don Quixote's character groups and fills the gap of insufficient attention to female characters in traditional studies.

b.This study will incorporate Gender and Power Theory (GPT), Feminist Theory, and other feminist ideas in order to reveal how the female characters in Don Quixote demonstrate a sense of independence in the face of societal pressures.

c.By analyzing the words and deeds, psychological activities and social status of female characters, this study further explores the gender norms and the mechanism of constructing female images in 17th century Spanish society, providing new ideas for Spanish literary studies and gender studies.

1.4.2 Practical Significance

a.In teaching practice, this study will help guide students through literary texts to understand the complex relationship between gender and power.

b.Provide insights into contemporary literature education through role-playing, scenario simulation and other teaching activities. Teachers can use the female characters in Don Quixote to guide students to understand gender equality, social power structures and the awakening of women's sense of autonomy, encourage students to think about the multiple roles of female characters in society, and thus cultivate critical thinking and a sense of social responsibility in students.

c.This study can also provide reference for contemporary literary criticism and film and television adaptations, and help creators understand the diversity and complexity of gender

discourse in classic literature.

1.5 Research Objectives

This study focuses on the portrayal of female characters in Don Quixote and explores their interaction with gender power relations. this paper aims to:

a.analyze the female characters or storylines in Don Quixote that exemplify gender power relations.

b.analyze how female characters in the novel demonstrate subjectivity and independence within a patriarchal system.

The exploration of these issues not only contributes to a deeper understanding of the novel's textual structure and characterization, but also reveals Cervantes' forward-thinking in terms of female consciousness.

2 Methods

2.1 Research paradigm

This study utilized the literature review method for the qualitative research design. This approach is appropriate because this study aims to analyze gender and power relations in Don Quixote by examining relevant literary texts, scholarly articles, and feminist theoretical frameworks. By synthesizing existing scholarship, this study will explore how Cervantes portrays the main female characters and their roles within the broader context of social and cultural power dynamics.

2.2 Design and Methodology

2.2.1 Data Gathering Tools

This study adopted a Systematic Literature Review (SLR) approach, aiming to sort out how female characters in Don Quixote can be interpreted from a feminist perspective, focusing on the ways in which gender and power relations are constructed in the novel. This review brings together scholarship that uses feminist literary theory to analyze Cervantes' work and distills from it key ideas about female characterization, gender dynamics, and social structures.

Research questions	(1)which female characters or storylines in Don Quixote embody gender power relations? (2)How do female characters in the novel demonstrate subjectivity and a sense of independence in the context of patriarchy?
Research strategy	Databases: Google Scholar, China Knowledge Network (CNN). Search terms: "Cervantes" and "Feminist analyses" "Don Quixote" and 'Feminist analyses'. "Don Quixote" and 'Gender and rights'. "Don Quixote" and "Female characters", "women's roles" "Don Quixote" and 'gender and power'
Inclusion Criteria	- Scholarship that focuses on female characters, feminism, gender, and power relations in Don Quixote - Explicit engagement with gender and power theory and feminist literary theoretical frameworks (e.g., liberalism, radicalism) - Textual close reading analysis of specific female characters or gender depictions
Exclusion Criteria	- Non-scholarly or non-peer-reviewed writing (e.g., blogs, reviews) - Literary criticism unrelated to gender or power - Research unrelated to the female characters of Don Quixote
Literature Screening and Selection Process	An initial search was conducted in accordance with the PRISMA 2020 guidelines, which yielded 95 articles. After de-duplication and review of titles, keywords and abstracts, 60 were retained for reading the full text for assessment. Eventually, a total of 12 literatures met the criteria and were included in the analysis of this study.
Data extraction and analysis methods	The included studies was coded and thematically analyzed, and the basic information extracted included: author, year of publication, theoretical framework used, object of analysis and key findings. Through qualitative thematic analysis (QTA), the following major themes was summarized in this study: - Women's existential dilemma and hierarchical embodiment under patriarchal structure in novels - The symbolic meaning and narrative function of female characters - Feminist role analysis
Limitations of the study	Although this review strives to be comprehensive, gray literature (e.g., unpublished essays, class transcripts, campus newspapers) that was not included due to copyright considerations and limited collection sources; some studies that did not explicitly use feminist terminology throughout may have been omitted after a keyword search.

2.2.2 Data Gathering procedures

The data collection process includes the following steps:

Identify primary sources, especially the English translation of Don Quixote and the original Spanish text.

Query literature that provides important insights into gender roles, feminist analysis, and power relations in Cervantes' work.

Sift through the collected literature, focusing on topics related to gender rights, female role images and power, etc., and summarize the ideas that can be drawn upon.

2.2.3 Treatment of Data

Thematic analysis was used to categorize the data based on recurring patterns and themes. Concepts such as feminism, gender and power relations, and resistance to traditional gender roles was central to the analysis. The structure of the findings is consistent with the research objectives, emphasizing how Cervantes portrays female roles in relation to power structures.

2.2.4 Ethical Considerations

Since this study only deals with published texts without direct human involvement, traditional ethical issues such as informed consent and confidentiality do not apply. However, this study followed appropriate citation practices to ensure intellectual integrity and academic rigor.

3 Result and Discussion

Although female characters are usually on the periphery of

the male-dominated world in the novels, their resistance is full of complexity, often not in direct confrontation, but in subtle confrontation through words, actions, or thoughts, challenging the social expectations and gender norms of women at the time. Through these characters, Cervantes not only reveals the social problem of gender inequality, but also reflects deeply on how women find space for their own survival in a male-dominated world.

The portrayal of these female characters below reveals the strict distribution of gender and power in Spanish society at the time, and the place of women in this social structure. Through these vibrant, vivid characters, Cervantes shows how women fought for autonomy, resisted oppression, and sought self-identity in the intersection of gender and social class in a patriarchal society. Although these female characters are in most cases the product of a male perspective, their presence and actions still reflect the complexity of women's position in the power structure, revealing a potential challenge to traditional gender roles and a call for gender equality.

Table1 The female characters that exemplify gender power relations

The female characters that exemplify gender power relations	(1)Dulcinea's idealization and the symbolism of gender roles
	(2)Teresa Panza's domestic roles and gender identity
	(3)Marcela - a symbol of the autonomous woman
	(4)Prostitutes and poor women - the intersection of gender and economic class

Table2 Female characters demonstrate subjectivity and independence within a patriarchal system

(1)Dulcinea
Related references: 1.Jin, W. (2021). An analysis of the character image of Dulcinea, the heroine of Don Quixote in Spanish literature. 2.Lin, Q. (2020). A brief analysis of the character image of Dulcinea, the heroine of Don Quixote. 3.Lu, S. (2024). The chivalric spirit of Don Quixote in the contradiction between ideal and reality. 4.Li, D. (2011). On the absentees in Don Quixote: The magician and Dulcinea. 5.Huang, J. (2024). A study on the narrative art of Don Quixote from a postmodern perspective.
Dulcinea is an avatar in the novel and is the ideal woman in Don Quixote's mind. Dulcinea is not portrayed as a character with an independent personality, but rather as Don Quixote's projection of her idealization, sanctification, and purity. Her presence profoundly influences the entire storyline and represents the portrayal of female characters by a male culture in which women are objectified, idealized, and fantasized to satisfy male needs and desires (Jin, 2021). This character portrays gender idealization bias and is a symbol of male gender power. In Don Quixote's eyes, Dulcinea is perfect and pure, and her image is thus one of the driving forces behind Don Quixote's actions. However, this idealized image reveals an important social reality: female characters are often shaped by male society and culture to fulfill male fantasy needs(Lin,2020). This gender construction not only expresses the male desire to control women, but also reflects the imposition and restriction of female identity in the society of the time, thus making her not only a vehicle for Don Quixote's extreme admiration of women, but also an embodiment of the idea of gender inequality. As Lu argues, the figure of Dulcinea is essentially part of a male power structure in which women have no real self-expression and exist only as objects of male fantasy (Lu, 2024). Modern scholars' understanding of Dulcinea, however, tends to be more complex. Lee, for example, mentions that Dulcinea's "absence" actually highlights her social symbolism as the "ideal woman". Dulcinea's inability to appear in reality is due to the fact that she does not represent a real woman, but rather a projection of male society's idealization of women. This idealization is not a mere love affair, but a limitation of the female role in terms of gender, morality and social norms (Li, 2011). Critics of modernism have argued that the existence of Dulcinea is only part of Don Quixote's fantasy and cultural structure, revealing gender inequality and the plight of women as "gender symbols". This role is a manifestation of how male society transforms the female role into a silent idealized object, which is not only a manifestation of gender oppression, but also a complete disregard for female individuality and independence, which shows how women in male-dominated societies are portrayed as objects of male desires, rather than as individuals with independence and subjectivity (Huang, 2024).
(2)Teresa Panza
Related reference: Ciallella, L. (2003). Teresa Panza's character zone and discourse of domesticity in Don Quijote.
Teresa Panza, the wife of Sancho Panza, a "big fat woman of thirty", is described as a traditional housewife with vulgar, greedy qualities that represent the traditional setting of female roles both inside and outside the home - as a supporter of men's lives as well as having to take care of domestic work and childcare. -both as a supporter of men's lives and as someone who must take on domestic labor and childcare responsibilities. From a gender perspective, the image of Sancho's wife reflects the expectations of society at the time regarding the role of the family and motherhood. It is a stereotypical image of women that symbolizes the society's fixation on female power and gender roles at that time. Ciallella argues that Cervantes portrays her in a humorous and ironic way, and that her maternal figure, although not portrayed as noble, still reveals the importance of women in the family and social structure (Ciallella, 2003). Sancho's wife is not only the traditional "good wife and mother" of gender expectations, but also the manager of the family economy, and it is through her interactions with Sancho that she demonstrates how women can increase their influence in the male-dominated family structure and further participate in the construction of the social power structure through the family role.

(3)Marcela

Related references:

1.Shen, W. (2014). A comparison of women's views in chivalric literature and martial arts literature from the East and the West.

2.Chu, G., & Li, Z. (2008). An interpretation of the aesthetics of Don Quixote from the perspective of psychological structure.

Marcela is an independent female figure in Don Quixote, she is a shepherdess, intelligent and kind, and countless people are bowled over by her beauty, however her cleanliness leads her to face several ill wills, those who pursue her furiously discredit her and pose as superior, attempting to bind her soul with traditional rules and self-righteously judge her morally. She rejects Amerigo's advances and defends her decision that she should not be bound by male desire. Marcela's rejection and her independent views on love and marriage contrasted with the social expectations of the time. In Spanish society at the time, women were often expected to follow traditional gender roles, such as marrying wives and mothers, whereas Marcela rebels against this structure by asserting her free will. Her independence is not just a rejection of male love, but an expression of a woman's sovereignty over her own body and mind (Shen, 2014).

As Chu and Li point out, her refusal was not callous, but her defense of her right to free choice, she expressed her insistence on women's autonomy through her words and attempted to break down men's expectations of women and the oppression of their gender roles through rational debates, such a courageous woman, possessing some of the most beautiful qualities of her time (Chu &Li,2008).

Marcela is a symbol of countless noble women, and the importance of this character lies in the fact that she is one of the few female characters in the novel who voluntarily chooses to be single and not dependent on a man. Her behavior challenges the social notion that love is a woman's vocation and demonstrates women's autonomy in making decisions about marriage and emotional life. Once upon a time, the deformed concept of marriage and love generally believed that when a woman reaches the age of 30, she is a leftover woman, and that women must get married and have children, and even women must give birth to a son to carry on the family line. The characterization of Marcela has vividly shaped a novel, enthusiastic history of women's growth, which is not a kind of spiritual guide to the women who are deeply disturbed by their relationships and marriages. Spiritual Guide.

(4)Prostitutes and poor women

The characters of prostitutes in the novels, such as the women encountered in the city, are often portrayed as morally corrupt, a portrayal that reveals both the inequality of gender and class and the double standards of society at the time regarding female sexuality. Female sexuality was scrutinized in society, and poor and lower-class women in particular were more susceptible to moral condemnation.

The most iconic of these prostitutes is the women encountered by Don Quixote and Sancho, who, although victims of gender oppression and social marginalization, engage in some form of power struggle with the male characters through their actions. Although their behavior is seen as "degrading," from a feminist perspective, the existence of these characters highlights the strong connection between gender and economic class.

Through these prostitute characters, Cervantes shows how women struggle to survive in the midst of poverty and gender oppression. Although the role of prostitutes has been criticized in traditional literature as that of moral failures, their existence reveals the dual oppression of women through economic poverty and social injustice. Women are often forced to enter "forbidden gender zones" in order to survive, and in the process their individuality and choices are completely stripped away. These roles are not socially acceptable, but they do raise criticisms of gender and social class structure in the context of the novel.

These above depictions of female characters not only reflect women's submissiveness and dependence, but also demonstrate women's subtle resistance within the male power structure. From Sancho's wife's efforts for her family, to Kilda's rejection of love, to the silent resistance of the prostitute character, Cervantes's portrayal shows how women, under the dual oppression of gender oppression and social class, seek to find a space for survival and a way to rebel in the midst of marginalization and deprivation.

4 Conclusion

Through an in-depth analysis of the female characters in Don Quixote, such as the idealization of Dulcinea, the traditional roles of mother and wife, and the independence of Kilda, and the marginalization of prostitutes and widows, we find that these characters, although usually relegated to a secondary position in traditional gender frameworks and bound to traditional gender roles and social norms, are by no means merely appendages to the male storyline or symbols of gender norms. symbols of the male storyline, they demonstrate potential challenges to the structures of social inequality through subtle ways of resistance and coping, fighting for autonomy in a patriarchal society, resisting oppression, and seeking self-identity in the intersection of gender and social class. Through his portrayal of these female characters, Cervantes reveals the inherent bias against women and the social structure of gender inequality in Spanish society, as well as the diversity and complexity of gender power relations in society. This is a potential challenge to traditional gender roles and a call for gender equality. Thus, Cervantes' work is not only a novel about male heroism, but also a profound reflection on gender and power structures. This essay provides a detailed analysis of the female characters in Don Quixote from a feminist perspective and explores how these characters reflect gender and power relations in Spanish society at the time. It is hoped that it will provide a valuable reference for scholars studying gender, literature and society.

5 Recommendations

Based on the findings of the study of the relationship between gender and power in Don Quixote, the following recommendations are made:

5.1 Curriculum development

Literature and gender studies educators may consider Don Quixote as a key text for exploring themes of gender dynamics and power relations.

Incorporating Don Quixote into curriculum design provides a valuable opportunity for educators to guide students in understanding how gender roles were constructed in early modern Spain, examining key female roles in relation to their historical

and cultural contexts and how these depictions reflect broader social hierarchies. By analyzing female roles and engaging students in discussions about gender and power dynamics, students can critically engage with historical representations of gender and their relevance to contemporary discussions of social justice.

In addition, combining Don Quixote with modern feminist theory can help students connect the gender power dynamics depicted by Cervantes to contemporary gender issues. By comparing the novel's female characters to modern media depictions of women, students can develop critical thinking skills that transcend the boundaries of literary analysis and encourage them to reflect meaningfully on enduring social structures.

5.2 Interdisciplinary teaching strategies

To deepen students' understanding of gender and power dynamics in Don Quixote, educators are encouraged to take an interdisciplinary approach, combining literary analysis with feminist theory, social psychology, and historical research. The incorporation of social psychology can further illuminate how power dynamics are represented in character interactions. Educators can also introduce students to the legal, religious, and social frameworks within which women lived in 17th century Spain, and with an understanding of these realities, students can see how Cervantes' female characters conformed to or resisted these expectations. By integrating these interdisciplinary approaches, educators can create a more dynamic and reflective learning environment in which students can examine the novel's female characters from multiple perspectives, thereby gaining a fuller understanding of their roles and the societal forces that shaped them, and even using Don Quixote as a text that challenges the assumptions about gender and power both in Cervantes' time and in contemporary society.

5.3 Further studies

The results of this study highlight the potential for an in-depth exploration of gender and power dynamics in Don Quixote. Future research could expand on these themes by comparing Cervantes' female characters to those in other early modern literature. Such comparative studies could reveal broader trends in how women's power was represented during this period, provide insight into how Cervantes' portrayal of women continues to resonate with and challenge contemporary readers, and also provide a richer understanding of how gender power relations operate across cultural boundaries.

Through these avenues of research, scholars can continue to reveal the subtle ways in which Don Quixote interrogates gender and power, ensuring the novel's relevance in current conversations about social justice and equality.

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Research On The Application Of Digital Monitoring In The Field Of Junior Golf Technology

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Abstract: In order to effectively improve the hitting level of the first wood swing of young golfers and improve sports performance, this paper conducted experimental research on 20 young golfers through the research methods of literature, experiment and mathematical statistics, and discussed the influence of digital monitoring application on the hitting effect of the first wood of young golfers. In this paper, the experimental group and the control group were set up, the experimental group was added with digital monitoring, and the control group received routine training. Finally, the conclusion was drawn that: After the experiment, the club head speed and the total distance of the first wood swing in the experimental group had significant positive effects, and were obviously better than the control group; Compared with the data before and after the test of the batting effect index of the No.1 wood swing in the experimental group, although the test results of the left and right Angle Index did not show significant difference, the effect was better than that of the control group with certain positive effects; Digital monitoring can effectively improve the level of young golfers' first-wood swing hitting skills, and students with good index test results will have better first-wood swing hitting effects. Therefore, in order to further improve the first-wood hitting effect of young golfers,digital monitoring equipment should be actively introduced in daily training to provide diversified teaching support and guidance for the improvement of young golfers hitting skills.

Keywords: Digital monitoring; Teenagers; Golf; First tree

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1 Introduction

With the continuous improvement of the quality of life of the Chinese people, many people have begun to pay attention to green life, and enhancing physical fitness and enriching the spiritual world have become the life pursuit of many people. Golf as a healthy, green aerobic leisure sport, since the development of our country has harvested more enthusiasts, golf is a high-level leisure sport, now gradually to the middle class of development, the participation group is more and more popular, its development and national policy also has a greater relationship. In March 2017, the "13th Five-Year Plan for the Development of Golf" mentioned that it is necessary to actively promote the widespread popularization of golf and accelerate the development of the golf industry. In November 2020, the "14th Five-Year Plan for Sports Development of the China Golf Association" also mentioned that it is necessary to further strengthen and improve the construction of golf events and service systems, expand the team of professional talents, and create a better social environment for the development of golf driving ranges.It can be seen that at present, China has given more policy support to the development of the golf industry, which has created a better development environment for it. In this context, more and more teenagers are joining the game of golf and becoming the backbone of promoting the development of golf. However, due to the immaturity of the young people's mental development, they do not have a high grasp of golf driver hitting skills. Therefore, the use of digital monitoring equipment to intervene in the hitting action of junior golfers has become a necessary measure to improve the hitting effect of junior golfers.

1.1 Purpose of the study

In golf, how to improve the driver hitting skills of junior students is a necessary measure to improve the golf skills of junior students. With the rapid development of digital technology, the use of digital monitoring equipment to intervene and train the batting action of junior players has become a new method for golf clubs to train junior players. In view of this, this paper explores the impact of digital monitoring on the hitting effect of golf drivers based on the characteristics of golf driver swing technology, hoping to promote the improvement of junior golfers' driver swing skills and provide a theoretical basis for other golf enthusiasts to improve the hitting level of drivers.

1.2 Research implications

1.2.1 Theoretical implications

At present, the literature on the application of digital monitoring in golf drivers is very scarce. Therefore, this paper designs a comparative experiment to observe the data of junior golf drivers by using the Trackman radar monitor, and reflects the impact of the hitting effect of junior golfers drivers through data comparison, and writes the research process into an academic paper, which can increase the literature on the application of digital monitoring in golf drivers.

1.2.2 Practical Significance

The application of digital monitoring in the junior golf driver

can be supported by data to allow teenagers to master the technical movements of the golf driver faster, as well as to deeply understand the principles of the golf driver and reduce technical action errors. At the same time, the digital monitoring equipment can analyze the action frame by frame, so that the teenagers can learn the golf driver more scientifically and rationally, so as to improve the skills of the junior golfers' drivers, reduce the number of strokes in the later stage, and comprehensively improve the hitting effect of the junior golfers.

2 Research objects and methods

2.1 Research Subjects

In this paper, the application of digital monitoring in junior golf driver technology was taken as the research object, and six junior golfers from Chongqing Baifu Riverview Golf Club were taken as the experimental objects.

2.2 Research Methodology

2.2.1 Documentation Law

By logging in to CNKI, consulting a large number of relevant literature on keywords such as "golf", "digital monitoring" and "golf driver", and searching for relevant materials through Internet query, this paper has laid a certain theoretical foundation for the development of this research.

2.2.2 Observation

Through field observation of the experimental subjects, we learned about the specific use of the Trackman radar monitor, and provided guidance to junior golfers when using the Trackman radar monitor in the field, which became the norm for the use of the Trackman radar monitor.

2.2.3 Experimental method

2.2.3.1 Test subjects

In this paper, six junior golfers from Chongqing Baifu Riverview Golf Club were selected as the test subjects, all of whom were between the ages of 13 and 16 years old, and there was no significant difference between the six junior golfers selected in terms of driver hitting technique and effectiveness. After a 3-month digital monitoring intervention with 6 teenagers, the effect of digital monitoring on the driver hitting of junior golf was verified by the driver hitting level of 6 junior golfers before and after the experiment. If teenagers can ensure a high training frequency and reasonable intensity, such as training multiple times a week, each training time is sufficient, then their skills will improve relatively quickly, and they may achieve better training results within three months, so the coach can set a detailed teaching plan according to it. Among them, among the 6 selected young players, they were numbered A, B, C, D, E, F, and the overall technical level was not much different, which met the experimental conditions. Among them, the age and skill level of 6 players are shown below.

Table 2.1 Skill handicaps for different players

	Gender	Age	Skill Level (handicap)
Player A	woman	16	13
Player B	woman	13	11
Player C	man	16	15
Player D	man	15	14
Player E	man	14	13
Player F	man	16	14

2.2.3.2 Experimental design

In order to explore the application effect of digital monitoring in junior golf driver technology, a before-and-after comparison experiment was designed, and K-VEST-3D was used to analyze the dynamics of junior golf driver before and after the experiment. The driver shots of six junior golfers before and after the experiment were compared. Among them, the monitor will score the player's performance based on the ball. Within a range of 160-210 yards from the target, no more than 20 yards from the target, the maximum score is 100 points, and the closer you are to the target, the higher the score. After 10 strokes, the system calculates the average score based on the player's performance in the individual event, which is the player's score over that distance. The digital monitoring technology used in this article is the Trackman radar monitor, which is a golf radar monitoring device developed by the Danish company TRACKMAN. K-VEST-3D, it is a professional-grade golf hitting body action data analysis system from the United States. The system uses 4 sensors to generate a 3D report of the golf swing, which can provide 3D images of the body and real-time data of the movement throughout the swing to help coaches and players understand the complexity of the swing and quickly analyze the problems of the golfers. Once the report is generated, the system also automatically recommends biodynamic training for athletes to improve swing deficiencies. Among them, during the 3-month training, its cycle training plan is as follows:

Table 2.2 The schedule of this experimental training cycle

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
8 : 30-9 : 00	Theory courses	Theory courses	Warm-up exercises				
9 : 00-10 : 00	Driver lead rod explanation	Driver half-waved explanation	Physical training	Driver full swing practice	Correct incorrect movements	Real grass stand tee exercises	rest
10 : 00-12 : 00	Driver lead rod training	Driver half-swing training	Aimed at physical stability training	Driver batting practice	Steady action	Off-field practice	

Among them, in the three-month experiment, the training plan of the 6 players was the same as the previous month, the theory explanation and the decomposition of the driver were practiced, and the real grass frame TEE practice was carried out after learning. In the second and third months, the movement correction and stabilization are carried out, and the swing plane

trainer is used to adjust the appropriate height and angle. Feel the correct swing trajectory, and then do a mirror exercise so that the teenager can see his swing and correct it. The difference is that the Trackman radar monitor is used for junior golfers in the second two months, and only the player's swing plus coach guidance is used for the second two months. The Trackman radar monitor uses dual radar technology, a high-frequency radar is used to complete the monitoring of the club, including the club path, face angle, rotation angle and attack angle. Another high-frequency radar is used to complete the monitoring of the ball, from take-off to flight and landing. The Trackman radar monitor provides the industry's most accurate real-time data and graphs of ball launch, flight and landing, monitoring the entire ball's trajectory with 99.7% accuracy. It can measure up to 23 sets of batting data, covering clubhead data (such as clubhead speed, clubface orientation, etc.), ball flight data (such as initial shot speed, maximum ballistic altitude, etc.), providing players and coaches with comprehensive and accurate information.

By using the Trackman radar monitor for the last two 6 golf balls to monitor the hitting of the driver, it helps players to understand their swing action, hitting effect and other indicators through the data provided by the Trackman radar monitor and the power swing sequence, and make a training plan for the player's problems, so as to help the player adjust his swing action and power mode when hitting the ball, and improve the accuracy and stability of the player's driver hitting the ball. At the end of each experiment, the results before the experiment were compared and analyzed, and the technical movements and training content of the players were adjusted to observe whether the players had significantly improved the distance from the driver and whether the body force sequence was becoming more and more smooth.

2.2.3.3 Experimental indicators

In order to further verify that digital monitoring can effectively improve the hitting effect of junior golf drivers, this paper selects three indicators: clubhead speed, experimental score and distance, which mainly evaluate the hitting technology of junior golf drivers. After a period of training, six junior golfers were measured on driver hitting technique.

2.2.4 Mathematical Statistics

The data were recorded and sorted by using the software Excel, and then the data obtained from the index test were analyzed by using the software SPSS 27.0.1 according to different conditions.

3 Research status at home and abroad

3.1 Current status of domestic research

Regarding the application of digital monitoring in the field of sports, Ji Qingge et al. (2023) investigated and analyzed 18 different sports and found that with the development of digital technology, digital monitoring technology, such as virtual reality and smart watches, has been introduced into different sports projects, which have become common digital monitoring devices to improve the efficiency of sports training.Meng Li (2023) pointed out that the use of digital monitoring in sports can present the athlete's sports status in digital form by analyzing the specific functions of digital monitoring equipment, so as to help athletes better adjust their training plans, correct wrong sports movements, and improve the training effect of athletes.Wang Meng and Yang Shaoxiong (2022) investigated the application of wearable devices in sports and found that national team athletes wear high-precision wearable devices during daily training, which can provide great help for employees to improve their own exercise efficiency by monitoring athletes' movement trajectory, heart rate, range of action and other data, and providing digital feedback in the background.Wang Baoqing (2019) used the SVT method to simulate the "eye health" training of players, and used digital technology to interfere with the visual changes of the athletes participating in the training, such as quickly changing the athletes' visual convergence, accommodation, saccade and tracking eye movements, so as to improve the visual perception of the athletes, thereby improving the hitting efficiency.

Regarding the research on the application of Trackman radar monitoring, Trackman radar monitoring is one of the most widely used digital monitoring devices in golf, so it has received extensive attention from scholars. Among them, Yao Bowen (2023) analyzed the application of Trackman radar monitoring in the golf technology evaluation system, and pointed out that the quality and efficiency of golfers' later training can be greatly improved by tracking and monitoring the athlete's hitting trajectory and other indicators by applying Trackman radar monitoring during golf technical training. Xu Shoujin (2022) analyzed the specific application of Trackman radar monitoring and found that in golf events, the application of Trackman radar monitoring equipment can quantify the data of golfers' tee-off, hitting, swing and other action characteristics, providing a reference for later technical improvement.Sun Meirong (2022) pointed out that the application of Trackman radar monitoring to golf technical training can monitor and identify golfers' action characteristics through radar, and then digitize the golfers' technical characteristics after uploading them to the back-end data processing center, which can provide a reference for improving golfers' hitting skills in the later stage. Xu Liguang (2019) pointed out that when Trackman radar monitoring is applied to golfers' training, it can simulate the ballistics of the game ball and remove the influence of weather factors through normal adjustment of the player's data analysis, so as to provide scientific guidance for golfers to improve their hitting skills .

3.2 Current status of foreign research

Shaw James et al. (2023) pointed out that the use of Trackman radar monitoring to improve golfers' hitting effect can accurately collect the player's serve data during each swing, including clubhead speed, hitting efficiency, attack angle, clubhead trajectory direction, clubface orientation, clubface dynamic elevation angle, etc., so as to provide more scientific guidance for improving golfers' technical effectiveness.Suzuki Takeru et al. (2021) used three Sony high-speed cameras to record the swing movements of six players in the World Golf Championship and analyze their driver swing techniques using three-dimensional motion, and made reasonable suggestions.Fisher Kevin M (2019) used a three-position capture system and Dartfish video analysis software to capture the relevant putting performance of the students in a non-laboratory environment, and analyzed and summarized the player's appropriate physical condition during the putting process, in addition to the player's general small putting angle compared to the pending.

3.3 Literature review

To sum up, through the review of relevant literature and theories, it is found that the current digital monitoring technology has received extensive attention from experts and scholars at home and

abroad, especially in the field of physical education teaching and training. In the field of golf, relevant research has begun at home and abroad. However, due to the late start of golf in China and the high price of related instruments and equipment, there are relatively few literatures on the application of digital monitoring technology to junior golf technical training. In this case, more research and exploration should be carried out on the digital monitoring technology of junior golf, hoping to improve the technology of junior golf and cultivate reserve talents through digital monitoring. Therefore, it is necessary to strengthen the research on the digital monitoring technology of golf teenagers on the basis of the research on physical fitness and psychology, and explore its application prospects in golf technical training.

4 Results and Analysis

4.1 Analysis of the hitting effect of the junior golfer's driver before the experiment

Prior to the experiment, the driver shots of 6 junior golfers were analyzed and the dynamics of the players' drivers were analyzed using K-VEST-3D. The score is determined by the distance of the driver, the angle of deflection between the left and right, and the distance difference between the target (200 yards) The closer to the target, the higher the score. Before the experiment, the full-swing batting effect of 6 people was counted, as shown in the following table:

Table 4.1 Data on the full-swing batting effect of junior golfers before the experiment

Project	Distance	Clubhead speed	Pre-experiment scores
Player A	175.66	69.23	79.2
Player B	170.89	70.63	76.5
Player C	190.1	75.14	88.65
Player D	182.56	76.56	85.12
Player E	178.91	75.61	82.64
Player F	195.3	73.66	90.96

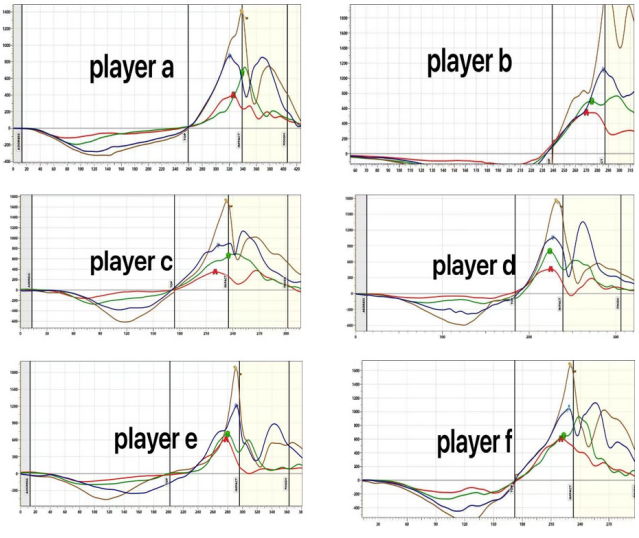

FIG 4. 1 Dynamic analysis of young players before the experiment

An analysis of the table above shows that prior to the experiment, the full swing distance of the six junior golfers ranged from 175.66 to 195.3 and the clubhead speed ranged from 69.23 to 76.56. In terms of overall score, player F has the highest score of 90.96, followed by player C with a score of 88.65, and player B has the lowest score of 76.5.

4.2 Analysis of the hitting effect of the driver of the junior golfer after the experiment

After the experiment, after two months of driver training, coach-specific training, and hard work by the teenagers, the driver hitting effect of the six junior golfers and the dynamic analysis of the players were analyzed. The score is determined by the distance of the driver, and the declination angle between the left and right sides and the distance difference between the target (200 yards) are the closer to the target, the higher the score. After the experiment, the full-swing batting effect of the 6 players was statistically counted, as shown in the following table:

Table 4.2 Data on the full-swing batting effect of junior golfers after the experiment

project	distance	Clubhead speed	Post-trial scores
Player A	181.56	78.9	86.22
Player B	185.79	74.99	87.56
Player C	202.8	81.88	96.22
Player D	194.56	73.79	91.12
Player E	205.89	81.56	96.32
Player F	186.23	80.63	88.23

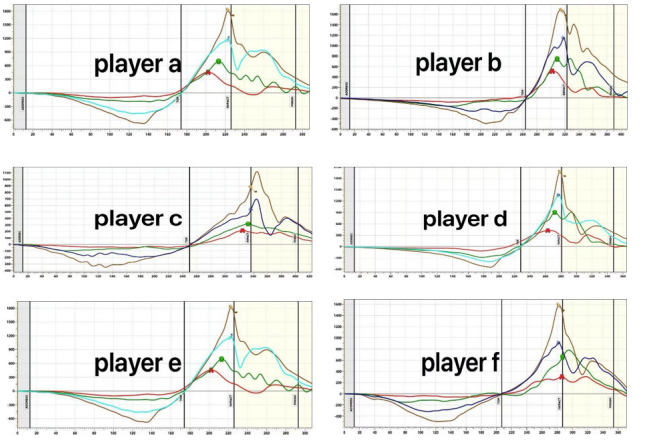

Figure 4.2 Dynamic analysis of young players after the experiment

Through the analysis of the above table, it can be seen that after a two-month digital monitoring intervention, the full swing distance of the six junior golfers was greatly improved, from 175.66 to 195.3 to 181.56 to 205.89. In terms of clubhead speed, it has also increased from 69.23-76.56 before the experiment to 73.79-81.88, which is a significant improvement compared with before the experiment, thanks to the joint efforts of players and coaches, only the players use trackman, and the intervention of coaches. In addition, in the score after the test, the highest score was increased from 90.96 to 96.32, and the lowest score was also increased from 76.5 to 86.22. It can be seen that after the use of digital monitoring intervention, the hitting effect of the teenagers' driver has been

significantly improved, and the hitting distance, clubhead speed, score, body force sequence and other aspects have been significantly improved.

5 Conclusions and Recommendations

5.1 Conclusion

After the experimental training of the experimental group, the clubhead speed and hitting distance of the driver swing in the experimental group were significantly improved, which was significantly better than that of the control group, indicating that the application of digital monitoring can effectively help junior golfers improve their driver swing skills.

Compared with the data before and after the test of the driver swing effect index in the experimental group, although the test results of the left and right declination index did not reflect a significant difference, the effect was better than that of the control group, which had a certain positive impact, indicating that in order to make the left and right declination of the hit more accurate, it was necessary to further use digital monitoring to adjust the hitting angle of the driver.

The application of digital monitoring can effectively improve the technical level of junior golfers' drivers, and the better the students' index test scores, the better their driver swing effect.

5.2 Recommendations

5.2.1 Introduce advanced digital monitoring equipment

In order to further improve the driver skills of junior golfers, golf clubs should actively introduce high-precision and multi-functional digital monitoring equipment, such as Trackman radar monitors, FlightScope, etc., which can provide comprehensive and accurate swing and shot data, including clubhead speed, shot angle, ball trajectory, etc. At the same time, it is necessary to pay attention to the upgrading of equipment, upgrade equipment in time to obtain more accurate and detailed data, and provide more adequate equipment support for junior golfers to improve their hitting skills.

5.2.2 Improve the way players are trained

In the traditional training of junior golfers, the demonstration teaching method and the error correction teaching method are mainly adopted, although these teaching methods have certain teaching effects, but the correction and demonstration of the hitting action of the junior golfers are very dependent on the coach's personal hitting ability and teaching experience. At the same time, for junior golfers, the different comprehension skills of individuals also make the effect of the driver greatly reduced. Therefore, by improving the training methods of junior golfers, introducing digital monitoring equipment, and enriching the training methods of junior golfers through digital monitoring technology, the training effect of junior golfers' hitting skills can be effectively improved.

5.2.3 Strengthen training on the use of digital equipment

In order to further play the role of digital monitoring equipment in promoting the hitting effect of junior golfers, on the one hand, we provide systematic digital monitoring technology training for coaches, so that they can be familiar with the functions and operation methods of various monitoring equipment, and master the skills of data analysis and interpretation. Through training, coaches are better able to use the monitoring data to develop personalized training plans for young players and provide targeted guidance. On the other hand, it is also necessary to educate young players on digital monitoring knowledge, so that they can understand the purpose, method and significance of monitoring, and improve their attention to monitoring data. At the same time, players are taught how to adjust their technical movements according to the monitoring data, so as to further improve the comprehensive hitting skills of junior golfers.

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The Construction of a Practical Teaching System for Accounting Majors in Higher Vocational Colleges Based on Outcome-Oriented Approach

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Abstract: Practical teaching is a key link in the cultivation of accounting professionals in higher vocational colleges. Based on the Outcome-Based Education (OBE) concept and in accordance with the demand for accounting talents in the industry and enterprises, this paper constructs a "three-dimensional integrated" practical teaching system, which takes the cultivation of students' job skills as the core and builds a "three-dimensional" practical teaching system of "single course training, discipline competition platform, and comprehensive internship and training". The three dimensions work in synergy to ensure the continuity of practical teaching and focus on cultivating high-quality, compound and innovative accounting talents who "know strategy, understand business, master finance, can analyze, are good at communication and diligent in learning", providing impetus for economic transformation and upgrading and high-quality development. It is expected to provide new approaches and practices for improving the practical teaching effect of accounting majors in higher vocational colleges, promote the adaptation of accounting work to digital transformation, and achieve the goal of "improving quality and efficiency" in reform and development.

Keywords: Outcome-Based Education; Higher Vocational Education; Accounting; Practical Teaching System

1 The Logical Origin Of Practice Teaching System Construction Of Accounting Major In Higher Vocational Colleges Under The Idea Of Outcome − Oriented

At present, the society highlights a situation: the number of college graduates is increasing year by year, but the phenomenon of graduates' employment difficulty coexists with the phenomenon of "labor shortage" and "difficult to find talent", and the structural contradiction of talent supply and demand is highlighted. With the high attention of the state, higher vocational schools have ushered in a good opportunity for development. However, it still faces many problems, such as how to better set the curriculum system of higher vocational schools according to the market demand, so that the talents trained can better meet the development needs of enterprises, how to fundamentally solve the highlighted structural contradictions, etc. As a higher vocational school, it is necessary to broaden the career development path, and continuously improve the professional practice teaching system that meets the needs of changes. To provide students with professional and effective vocational education services, and continue to become an indispensable and important force in the supply of high-quality technical and skilled personnel in the country.

The essence of outcome-oriented (OBE) concept is output-oriented and follows the principle as follows: the design process of teaching activities is carried out in the reverse mode, and the development of teaching activities is carried out in the forward mode. In the teaching process, students should be regarded as the main body, and what kind of teaching system should be focused on? What outcomes can it help students achieve? All relevant teaching activities carried out in the whole process of education and teaching activities are goal-oriented to enable students to obtain the best learning results.

Accounting is a major with strong application. Based on the outcome-based learning (OBE) concept, this paper constructs the practice teaching system of accounting in higher vocational schools, focusing on the current social environment and the transformation and upgrading of accounting industry, and focusing on the focus of education and teaching to achieve the best learning results for students. It is of practical significance to train students to master the latest knowledge and skills synchronized with social development, improve their ability to solve problems independently, and meet the new needs of social and economic development and construction.

2 The Entry Path Of The Construction Of Practice Teaching System Of Higher Vocational Accounting Under The Concept Of Outcome− Oriented

In the education and teaching activities of higher vocational schools based on major and practice, the outcome-oriented (OBE) concept adheres to the goal of "entering the school and entering the post after graduation". Its essence connotation lies in solving four key problems: what kind of learning results can students obtain through the study of their major? What is the point of achieving such learning outcomes? What pathways help students achieve the desired learning outcomes? What methods are used to evaluate the learning outcomes achieved by students?

The essential connotation of outcome-based education

(OBE) concept and the key to the construction of practical teaching system are the following four points: first, based on the essential connotation of outcome-based education, how to efficiently cultivate students' practical application ability and innovation and entrepreneurship ability? Second, based on the output oriented era value, how to view the strategic needs of talent power? Third, how to construct the practice teaching system based on the output oriented access path? Fourth, based on the output oriented multi-dimensional evaluation, how to practice the comprehensive evaluation inside and outside the school? To sum up, the essence of outcome-oriented (OBE) concept and the entry path architecture of practical teaching reform are shown in Figure 1.

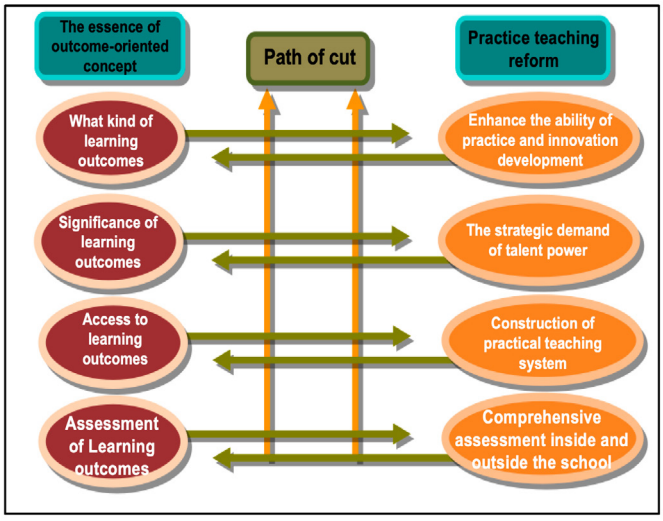

Figure 1: The essence of outcome-based learning (OBE) concept and the entry path structure of practical teaching reform

From Figure 1, we can find that the entry path of the two lies in the following aspects:

2.1 Establish the Essence of Learning Outcomes

The description of practical application ability and innovative development quality in the training objectives of accounting major in higher vocational schools is: to have basic professional knowledge of accounting, be familiar with relevant knowledge in the field of statistics and computer, realize the integration of business and finance in the daily business operation and production activities of enterprises, reduce enterprise costs, improve enterprise performance, enhance enterprise value, and embody innovative quality in practice.

The description of practical application ability and innovative development ability in the graduation requirements supporting this training objective is as follows: while mastering basic accounting professional knowledge, I should have the ability to use big data to analyze and make decisions, risk control ability, business analysis ability and prediction and decision-making ability, so as to realize the improvement of enterprise value and reflect the innovation and development ability in practical application. The structure of accounting expertise is shown in Figure 2.

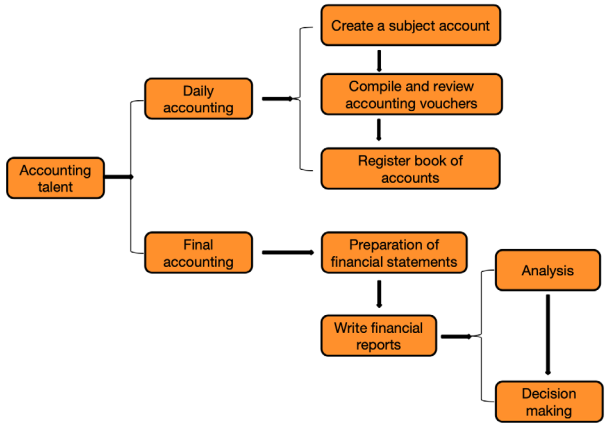

Figure 2: Professional knowledge structure of accounting talents

2.2 Understand the Contemporary Value of Learning Outcomes

At present, our country is thoroughly implementing the strategy of strengthening the country with talents in the new era, and urgently needs a group of compound accounting talents who are proficient in professional and familiar with information technology, strategic thinking and innovative ability. As one of the important bases for the training of accounting personnel, higher vocational schools undertake the important responsibility of suppleming and updating the knowledge of accounting personnel, expanding the knowledge structure, improving the comprehensive practical quality and innovative ability. Therefore, based on the outcome-based learning (OBE) concept, this paper implements practical teaching reform, constructs a "three-dimensional integration" practical teaching system, improves the quality of talent training, promotes accounting talents to adapt to digital transformation, forms a new pattern of differential positioning and collaborative development, and builds a large platform for cooperation and win-win. The strategy of strong country needs talent skills and professional training of accounting talents as shown in Figure 3.

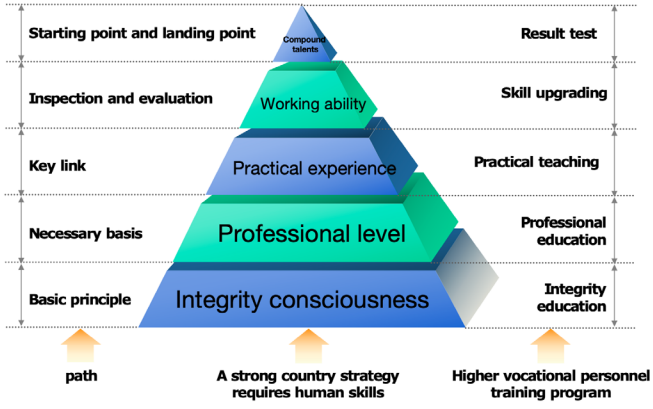

Figure 3: Talent skills and professional training of accounting talents are required under the concept of results-oriented (OBE)

2.3 Access to learning outcomes

Through the analysis of the current practice teaching system of higher vocational accounting, the cultivation of students' practical

ability mainly depends on the theoretical teaching, with the school simulation experiment, enterprise post practice, accounting skills competition, accounting professional qualification certificate examination and other activities. However, in the development of specific teaching practice activities, there is a lack of effective connection, lack of systematicness and hierarchy, lack of time and scientific nature, lack of rationality and coordination. Therefore, the practice teaching system of higher vocational accounting should adhere to continuous improvement, change from static compliance to dynamic reform, take the market demand as the guidance, take talent training as the center, formulate practice teaching quality assurance mechanism to meet the needs of professional practice teaching.

2.4 Multi-Dimensional Assessment of Learning Outcomes

After the practical teaching, students' learning outcomes need to be evaluated. The evaluation path is the two-way combination of inside and outside the school, the process evaluation is the main method inside the school, and the goal evaluation is the main method outside the school. In the whole evaluation process, we should focus on the learning results obtained by students in daily education and teaching activities, take the best learning results as the goal orientation, improve students' professional quality, strengthen students' practical skills, and deepen the cultivation of students' practical innovation ability.

3 The Construction Of Practical Teaching System Of Higher Vocational Accounting Based On Outcome-Oriented

Based on the outcome-based learning (OBE) concept, it emphasizes the combination of talent training and social needs. According to the route of "demand-oriented + precise implementation + continuous improvement", it takes students to obtain the best learning results as the goal orientation, and combines with the new needs of the current society, and defines the training objectives of accounting professionals. To develop the skill index system that students need to master when they graduate, and explore the construction of practical teaching system that keeps pace with The Times. Figure 4 shows the design of the "three-dimensional integration" practical teaching system of talent training based on the outcome-based learning (OBE) concept.

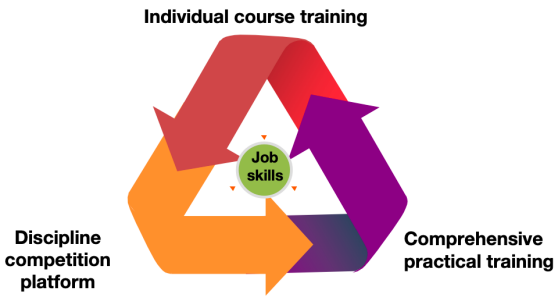

Figure 4: The practical teaching system under the results-oriented (OBE) concept ——Three-dimensional integration

Figure 4 shows that the practice teaching system of higher vocational accounting major is guided by "learning results" and based on the post skills needed by society, and constructs a "three-dimensional" practice teaching system of "individual course training, discipline competition platform and comprehensive practice training" that can support the achievement of results.

Single course training is implemented in the form of case teaching, based on discipline-related professional skills competition, to promote learning and further deepen students' understanding of the course. The content of comprehensive practice training courses is focused on professional skills training and professional comprehensive quality improvement, through professional practice experience of real business operation, reflection on problems in work, improve practical operation ability. Constantly summarize and analyze the students' comprehensive learning results, keep pace with The Times to optimize and improve the existing practice teaching system, and strive to cultivate students into skilled and intelligent talents in the current era.

3.1 Build the path

Consolidate the foundation and strengthen the practice. Based on the practical teaching activity platform, through the cost accounting experiment, advanced accounting experiment, accounting informatization experiment, intelligent tax experiment, ERP sand table simulation training, big data financial management experiment and other single training projects to improve students' core competence.

Based on competition, encourage innovation. It is deeply understood that participating in discipline competition is an important way to promote teaching reform. By establishing a good mechanism to promote learning and teaching through discipline competition, the standards and content of excellent discipline competition are introduced into curriculum teaching, and students are guided to actively participate in recognized, influential and suitable competition projects. For example, the intelligent Accounting competition of the Belt and Road and BRICS Skill Development and Technology Innovation Competition (higher vocational group), "Foster Cup" National College Students Audit Elite Challenge (higher vocational group), "Keyun Cup" national vocational colleges Accounting professional ability competition, Internet + College students Innovation and Creativity Competition, "Youth" National college students Entrepreneurship Competition, Challenge Cup and other national large-scale Through the competition, students can further understand and apply the knowledge they have learned, cultivate their practical ability and professional quality, enhance the training of innovative thinking, and stimulate their awareness of independent innovation.

School-enterprise cooperation and linkage education. "Point on" precise breakthrough, cooperation with key enterprises; "Online" efficient integration, cooperation with relevant functional departments, and actively strive for policy support and business guidance. "On the surface", we will comprehensively spread out, grasp policies in advance, and further expand cooperation areas, further deepen cooperation levels, and further improve cooperation mechanisms with the help of powerful platforms. We should find out the focus and breakthrough points of cooperation, make precise efforts, promote the integration of production and education, and achieve the teaching goal of "entry into the job immediately after admission and employment immediately after graduation".

3.2 Construction measures

Will need to be honest, plan to practice. If accounting information is distorted, then the market economy will be out of order. Therefore, higher vocational schools should focus on building a modern accounting training center integrating practical training teaching, scientific research, innovation and entrepreneurship, which should be equipped with several training rooms, such as accounting comprehensive training room, modern business practice center, securities simulation trading practice training room, ERP laboratory, etc. At the same time, it is supplemented by Yonyou ERP software, securities simulation trading operating system, tax declaration software, audit and other software systems, combined with the financial processing process under the information system, forming an on-campus simulation training system of "teaching, learning, and doing integration", providing a place for students to project training, competition training, and imitation of real operation, and adhering to the work goal of improving the employment rate and employment quality. In the process of combining theory with practice, students should adhere to the professional ethics of "Ming Tao and thick morality, brave bear innovation, rigid and tenacious, erudite and elegant", and develop the working habit of abiding by good faith.

Relying on the industry, expand the carrier. Accounting is not only a professional technology with technical attributes, but also a balanced management art with social attributes. In the process of implementing the principle-oriented enterprise accounting standards, the professional skills of accounting practitioners are required to be higher. It is an efficient measure for higher vocational schools to cultivate skilled talents by mutual cooperation between schools and social enterprises. In the whole process of education, it is a combination of deepening innovation of theory and practice by taking the actual needs of enterprises as the goal orientation. Higher vocational schools should attach great importance to school-enterprise cooperation, deepen cooperation in curriculum setting, talent training, teacher sharing, internship training, enrollment and employment, match the advantages of both sides, jointly create an optimal practical teaching system of "linkage education, joint management process, joint achievement", and establish a number of practical training practice bases. The scope of the base can be extended from the local region to the whole province and developed areas outside the province, so that the school-enterprise cooperation project can effectively play the synergistic and win-win social benefits, and strive to improve the high-quality employment and professionalism of students. The cooperative units can involve high-tech, trade, service, construction and other types of enterprises. Based on the standards of enterprise employment, the students' job ability is the goal, the real account operation of the enterprise is the training content, the production environment is the teaching environment, and the students' practical ability and comprehensive quality of the workplace is the starting point, so as to realize the seamless connection between the school and the enterprise employment needs. First, based on its own educational advantages in the industry, undertaking the construction of the provincial financial cadre training center and the establishment of the basic skills training base for certified public accountants, and actively integrating into the CPA industry talent team construction system; Second, relying on the industry influence of provincial and municipal injection associations, jointly build dual-teacher workstations, and improve the supporting system and mechanism of government, industry, school and enterprise cooperation; The third is to jointly build order classes with accounting firms and carry out the pilot modern apprenticeship system for basic skills talents. In the process of practical training, students and internship units can sign the "Modern apprenticeship talent training cooperation agreement" to clarify the responsibilities and obligations of family, enterprise and school, and achieve the idea and goal of school, enterprise and society to jointly cultivate students and develop students.

Multi-dimensional test, continuous improvement. The construction and optimization of practice teaching system of accounting major in higher vocational schools should be based on students' practice and learning results, and adopt diversified evaluation standards. The evaluation results can be expressed as "meet/do not meet", "achieve/fail to achieve", "pass/fail" and so on. The results can be tested both inside and outside the school. The on-campus test can refer to the process participation and performance assessment standards, the quality of link homework, the learning achievement sharing and exchange inspection standards, the level of various majors and comprehensive competitions, the participation of scientific research projects, the publication of professional papers, the quality of graduation design (thesis), the application ability of professional theoretical knowledge and other aspects of comprehensive evaluation, and the off-campus test can refer to the off-campus education teaching basis Local assessment standards, social questionnaire results, enterprise survey visits, internship evaluation standards, internship work report quality, post performance evaluation, post sustainable development ability test and other forms of comprehensive evaluation, through the campus and off-campus combination of multi-dimensional inspection to comprehensively evaluate students' final practice results, the evaluation results and training objectives were compared and analyzed. To improve the school-enterprise two-way teaching evaluation system with the main line of cultivating students' ability and the enterprise evaluation of students' internship and practical training as the leading part, and the comprehensive teaching quality evaluation and monitoring mechanism of schools, employers and parents, improve the shortcomings of the practice teaching system, and ensure that the practice teaching activities of higher vocational accounting can accurately grasp the characteristics of teaching objects. Efforts should be made to cultivate high-quality compound innovative accounting talents who "know strategy, business, finance, analysis, communication, and study frequently", so as to provide momentum for economic transformation, upgrading, and high-quality development.

4 Conclusion

In the training of accounting professionals in higher vocational schools, practical teaching system occupies a crucial link. In this teaching link, students rely on solid theoretical knowledge and innovative practical thinking, in contact with real various actual economic business processes and data, shape the high-quality compound innovative accounting talents who "know strategy, understand business, fine finance, can analyze, good communication, and often study". With the support of scientific theories and methods, this paper innovates ideas to deepen the four-dimensional connection of "teaching standards connecting

professional standards, teaching content connecting work business, training context connecting business reality, academic evaluation connecting enterprise assessment", solve the problem of talent supply and demand, promote the high-quality development of vocational education, promote the quality and efficiency of skill talent training, and fit the strategy of strengthening the country with talents in the new era. Cultivate compound accounting talents who are proficient in professional and familiar with information technology, have strategic thinking and innovative ability.

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Research on Reconstructing the Educational Value of Failure Experiences in Gamified Learning

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Abstract: This study explores the reconstruction of the educational value of failure experiences in gamified learning, aiming to provide theoretical and practical guidance for optimizing learning processes. The research systematically analyzes the current status and problems of failure experiences in gamified learning, and clarifies their educational values in three dimensions: cognitive development, emotional attitudes, and social skills. Theoretically, failure experiences can stimulate learners' reflection, deepen knowledge understanding, cultivate critical thinking, enhance frustration tolerance, motivate learning, and improve social interaction abilities. Practically, strategies for reconstructing educational value are proposed, including goal-oriented design with contextual elements, cognitive guidance through failure education and role models, and interactive reinforcement via timely feedback and technological tools. Empirical results show that the experimental group using reconstructed strategies significantly outperforms the control group in learning motivation, academic performance, and attitudes toward gamified learning. The study fills academic gaps in gamified learning theories, offers actionable insights for educators and developers, and highlights the need for expanded sample scope, enhanced qualitative research, and long-term strategy validation in future studies.

Keywords: Gamified learning; Failure experiences; Educational value; Reconstruction strategy; Cognitive development; Emotional attitudes; Social skills

1 Introduction

1.1 Research Background

1.1.1 The Rise and Development of Gamified Learning

With the rapid advancement of information technology and the continuous update of educational concepts, gamified learning has gradually emerged and gained widespread attention. Gamified learning integrates game elements and mechanisms into traditional learning processes, aiming to enhance learners' participation and motivation by increasing the fun and interactivity of learning. Historically, early educational games were relatively simple, mainly presenting basic learning content in game forms, such as simple word-spelling games or math-operation games. However, with technological progress, the forms of gamified learning have become increasingly diverse, incorporating cutting-edge technologies like virtual reality (VR) and augmented reality (AR), which enable learners to immerse themselves in various learning scenarios. For example, in history learning, VR technology can recreate historical scenes, allowing students to feel as if they are in a specific historical period and enhancing their perception and understanding of historical events. Meanwhile, the application scope of gamified learning has expanded from basic education to higher education, vocational training, and corporate internal training. In corporate training, simulations of business scenarios through games help employees improve their professional capabilities and teamwork skills. This rise and development reflect the education sector's reflection on traditional teaching methods and active exploration of innovative learning models.

1.1.2 The Current Status and Attention to Failure Experiences in Gamified Learning

While gamified learning is booming, failure experiences, as a critical aspect, have not been sufficiently studied. Traditional gamified learning designs often focus more on enabling learners to complete tasks successfully and obtain rewards to reinforce motivation, while neglecting the potential value of failure experiences in the learning process. In fact, failure is an inevitable part of learning, which can prompt learners to reflect on their behaviors, adjust learning strategies, and achieve deeper learning. In some complex gamified learning scenarios, learners may encounter frequent failures—for instance, in simulated entrepreneurship games, failures may occur due to misjudgments of market trends or improper financial management. Currently, however, there is relatively little research and practice on how to design failure experiences reasonably to both stimulate learners' motivation and prevent them from giving up due to excessive frustration. Although some researchers have begun to focus on this field in recent years, the study of failure experiences in gamified learning remains largely in its infancy and urgently requires more exploration and attention.

1.2 Research Objectives and Significance

1.2.1 Research Objectives

This study aims to deeply explore the design and application of failure experiences in gamified learning. Specific goals include: analyzing the manifestations and influencing factors of failure experiences in different types of gamified learning scenarios; constructing a scientific and reasonable failure experience design model to guide the development of gamified learning products; and verifying the impact of the designed failure experiences on learners'

academic performance, motivation, and emotional attitudes through empirical research. Achieving these objectives is expected to provide more targeted and effective design strategies for failure experiences in gamified learning, optimize the learning process, and enhance learning quality.

1.2.2 Theoretical Significance

Theoretically, this study contributes to enriching the theoretical framework of gamified learning. Current theoretical research on gamified learning mostly focuses on the application of game elements and the stimulation of learning motivation, with relatively limited discussions on failure experiences. This study will deeply analyze the internal relationship between failure experiences and the learning process, and reveal the mechanisms by which failure experiences promote learners' knowledge construction, skill development, and emotional growth from multidisciplinary perspectives such as cognitive psychology and educational psychology. This not only provides new perspectives and content for improving gamified learning theories but also expands the research scope on learning processes and mechanisms in the education field, offering a theoretical foundation and reference for subsequent related studies.

1.2.3 Practical Significance

Practically, the research results have important application value. For educators, understanding how to design effective failure experiences can help them better use gamified learning methods in teaching, guide students to face failures correctly, and learn from them to improve learning outcomes. For example, when designing online courses, educators can reasonably set levels and challenges based on the failure experience design model proposed in this study, allowing students to grow through moderate failures. For game developers, the failure experience design strategies provided by this study can guide them to create more educationally valuable gamified learning products and enhance user experience and educational effects. Additionally, for corporate training departments, introducing scientifically designed failure experiences can improve the quality and efficiency of employee training, cultivating their problem-solving abilities and adaptability to changing market environments.

1.3 Research Methods and Technical Route

1.3.1 Research Methods

Literature Research Method: Extensively collect academic literatures, research reports, and relevant policy documents on gamified learning, failure experiences, and educational psychology at home and abroad. Through systematic review and analysis of these literatures, gain insight into the research status, development trends, and existing problems in the field, providing a solid theoretical foundation and research starting point for this study.

Case Analysis Method: Select representative gamified learning cases, including educational games and gamified modules in online learning platforms, and conduct in-depth analysis of the design and application of failure experiences in these cases. Through comparative analysis of different cases, summarize successful experiences and shortcomings, providing practical evidence for proposing failure experience design strategies later.

Empirical Research Method: Design and carry out empirical studies by selecting appropriate research subjects (e.g., school students or corporate employees). Divide the subjects into an experimental group and a control group, where the experimental group adopts a gamified learning scheme with failure experiences designed based on this study, while the control group uses traditional gamified learning schemes. Collect data on learners' academic performance, motivation, and attitudes through pre-tests, post-tests, and process evaluations, and use statistical methods to analyze the data and verify the impact of the designed failure experiences on learning outcomes.

1.3.2 Technical Route

The technical route of this study is as follows: First, clarify research questions and objectives through literature research and construct a theoretical framework. On this basis, use case analysis to summarize the experiences and problems of failure experience design in existing gamified learning cases. Then, propose failure experience design models and strategies based on theoretical research and case analysis. Next, design an empirical research plan, including subject selection, experimental variable control, and development of data collection tools. Implement the empirical study, collect and analyze data, and verify research hypotheses. Finally, optimize and refine the failure experience design models and strategies based on empirical results, form research outcomes, and promote their application.

1.4 Research Content and Innovations

1.4.1 Overview of Research Content

This study focuses on failure experiences in gamified learning, with specific content including: 1) Clearly defining relevant concepts of gamified learning and failure experiences to clarify the research scope; 2) Deeply analyzing the mechanisms of failure experiences in gamified learning, discussing their impacts on learners from cognitive, emotional, and behavioral dimensions; 3) Summarizing common patterns and problems in current failure experience design through analysis of numerous cases; 4) Constructing a scientific and reasonable failure experience design model based on theoretical research and practical analysis, including the design of key elements such as failure frequency, intensity, and feedback methods; 5) Verifying the effectiveness of the constructed failure experience design model through empirical research and exploring its impacts on learners' academic performance, motivation, and emotional attitudes.

1.4.2 Innovations

Theoretical Perspective Innovation: This study adopts a multidisciplinary integration perspective, comprehensively applying knowledge from educational psychology, cognitive psychology, and game design theory to deeply analyze the mechanisms of failure experiences in gamified learning. Compared with previous single-discipline studies, this multidisciplinary approach can more comprehensively and deeply understand the internal relationship between failure experiences and learning processes, providing new ideas and methods for the development of gamified learning theories.

Failure Experience Design Innovation: This study proposes a failure experience design concept based on "personalization" and "dynamic adjustment." Traditional failure experience designs often use uniform standards and models, ignoring learners' individual differences and the dynamics of the learning process. In contrast,

this study designs failure experiences according to learners' learning styles, knowledge levels, and progress, and dynamically adjusts failure difficulty and feedback methods based on learners' real-time performance during learning to better meet their needs and improve learning outcomes.

Research Method Innovation: In empirical research, this study will comprehensively use multiple data collection methods. In addition to traditional questionnaire surveys and test scores, advanced technical tools such as eye-tracking and EEG monitoring will be introduced to collect physiological and psychological data (e.g., cognitive load and emotional engagement) during learners' gamified learning processes. Through integrated analysis of multi-source data, this approach can more accurately evaluate the impact of failure experiences on learners and provide more scientific and precise evidence for failure experience design.

2 Related Theories and Research Review

2.1 Theories Related to Gamified Learning

2.1.1 Conceptual Definition of Gamified Learning

Gamified learning, in simple terms, refers to the use of game-like approaches for learning, where teachers utilize games to convey specific knowledge and information to learners. It mainly includes two categories: digital games and game activities. In educational contexts, gamified learning integrates game elements such as points, leaderboards, badges, and tasks into non-game learning environments to enhance the (fun) and attractiveness of learning, thereby stimulating learners' intrinsic motivation and participation. For example, in language learning, role-playing game activities can be designed to allow students to use the target language for communication in simulated real-life scenarios, making the learning process more contextual and interactive. This learning approach aims to break the monotonous pattern of traditional teaching, enabling learners to acquire knowledge and improve skills in a relaxed and enjoyable atmosphere.

2.1.2 Theoretical Foundations of Gamified Learning

Behaviorist Learning Theory: This theory emphasizes that learning is a connection between stimuli and responses, with behavior shaped through reinforcement. In gamified learning, elements like points and rewards can be seen as reinforcements for learners' correct behaviors, prompting them to repeat desired learning actions. For instance, when a student solves a math problem and receives point rewards, this positive reinforcement motivates them to solve more problems, thereby enhancing their mathematical abilities.

Cognitivist Learning Theory: Focused on the study of learners' internal mental processes, this theory views learning as an information-processing activity. Various tasks and challenges in gamified learning can be regarded as information inputs, which learners process through thinking, analysis, and problem-solving to internalize knowledge. For example, in puzzle-based gamified learning, students must use existing knowledge and logical thinking to solve puzzles, a process that involves information processing and knowledge construction.

Constructivist Learning Theory: This theory emphasizes learners' active constructive role in the learning process, arguing that learning occurs when learners, in a specific context and with the help of others (including teachers and peers), use necessary learning materials to construct meaning. Gamified learning provides rich contexts and interactive opportunities, where learners interact with the environment and peers through exploration and trial, constructing their own understanding of knowledge. For example, in simulation business games, students understand the principles of economic management through practicing virtual enterprise operations.

2.2 Research on Failure Experiences

2.2.1 Research Findings on Failure Experiences in Psychology

In the field of psychology, failure experiences have been widely studied, with research showing their multifaceted impacts on individual psychology. Emotionally, failure often triggers negative emotions such as frustration, anxiety, and disappointment. For example, individuals who fail an important exam may fall into self-blame and frustration, doubting their own abilities. However, appropriate failure experiences can also serve as opportunities for growth. Some studies have found that if individuals correctly attribute failure—attributing it to insufficient effort rather than ability deficits—they may be motivated to strive for success, learning from failures to adjust their behavioral strategies and achieve better results in subsequent tasks. Additionally, failure experiences are closely related to self-efficacy. Continuous failures may reduce self-efficacy, making individuals lack confidence in their ability to complete tasks, while occasional failures overcome with success may enhance self-efficacy, enabling individuals to believe in their capability to meet challenges.

2.2.2 Research Status of Failure Experiences in Education

In the education field, failure experiences have also received attention, with studies highlighting their significant impact on students' learning and development. On one hand, excessive failure experiences may lead to weariness of learning and reduced motivation. For example, students who frequently fail in math learning may gradually develop fear and avoidance of the subject. On the other hand, rational use of failure experiences can promote learning. Teachers can guide students to reflect on failures, analyze causes of errors, and deepen their understanding and mastery of knowledge. Research has shown that in experimental teaching, students' failure experiences (such as failed experiments) can enrich their learning experiences, prompting them to think about improving experimental methods and enhancing practical abilities. For instance, Zong Guoqing and Chen Mingrui used educational phenomenological methods to study students' experimental failure experiences and concluded that chemistry experiment failures (including accidents) involve rich experiences, whose enhancement or reduction is influenced by multiple factors (teacher guidance, peer cooperation and competition, personal efforts, and time) acting singly or interactively. Moreover, numerous studies on the manifestations and impacts of failure experiences across different subjects and age groups provide theoretical bases for educators to guide students in coping with failures.

2.3 Research Progress on Failure Experiences in Gamified Learning

2.3.1 Key Focuses of Existing Research on Failure Experiences in Gamified Learning

Existing research primarily focuses on the impacts of failure experiences in gamified learning on learners' motivation and behavior. On one hand, studies have found that failure experiences may negatively affect learners' motivation. If failures in games are too frequent or insurmountable, learners may feel frustrated and reduce their enthusiasm for participating in gamified learning. For example, in competitive gamified learning, frequent failures may make learners feel inferior to others and lose motivation to continue. On the other hand, some studies suggest that moderate failure experiences can stimulate learners' desire to challenge and explore. When learners encounter failures but believe they can overcome them through effort, they may become more engaged in attempts to achieve success. Additionally, existing research has focused on optimizing failure experiences through game design—for example, setting reasonable failure feedback mechanisms that enable learners to clearly understand the causes of failure and provide corresponding improvement suggestions to help them avoid repeated failures in subsequent games.

2.3.2 Gaps and Limitations in Current Research

Despite existing studies on failure experiences in gamified learning, several gaps and limitations remain. First, in terms of research methods, most studies rely on questionnaires and experimental methods, with few dynamic tracking studies on learners' real-time psychological and behavioral changes during gamified learning. This makes it difficult to fully understand how failure experiences evolve throughout the learning process and their long-term impacts on learning outcomes. Second, there is a lack of in-depth research on differences in failure experiences across different types of gamified learning (e.g., role-playing, puzzle-solving, simulation management). Different types of gamified learning have distinct characteristics and rules, and failure experiences may manifest and impact learners differently, but current research has not systematically analyzed these differences. Third, there is a shortage of research on specific strategies and methods for applying failure experience research results to practical teaching. Although we know theoretically that failure experiences are important for learning, more practical guidance is needed on how to cleverly design failure scenarios and guide students to cope with failures in real teaching.

3 Analysis of the Current Status of Failure Experiences in Gamified Learning

3.1 Common Forms and Application Scenarios of Gamified Learning

Gamified learning integrates game elements with the learning process to enhance learners' engagement and motivation. It is widely applied in various fields with diverse forms.

3.1.1 Application of Gamified Learning in School Education

In school education, gamified learning often takes the form of classroom interactive games and subject competition games. For example, in mathematics classes, teachers can design number-puzzle games where students compete in groups through quiz and problem-solving sessions, not only reinforcing mathematical knowledge but also cultivating teamwork and competitive awareness. In language classes, role-playing games can simulate real-life scenarios for students to practice dialogues, improving their language expression skills. This form transforms traditional boring knowledge learning into interesting game activities, allowing students to acquire knowledge in a relaxed and enjoyable atmosphere and enhancing their learning initiative.

3.1.2 Gamified Learning Models on Online Learning Platforms

Online learning platforms offer diverse gamified learning models. Many platforms adopt point systems, where learners earn points for completing tasks, participating in discussions, etc., which can be exchanged for virtual rewards or unlock new learning content to motivate continuous learning. Some platforms design learning levels similar to game challenges, where learners must pass the current level's test to proceed to the next stage, increasing the challenge and fun of learning. Additionally, leaderboard functions are common gamified tools, allowing learners to see their rankings within classes or the platform, stimulating competitive psychology and encouraging harder work.

3.1.3 Practices of Gamified Learning in Vocational Training and Other Scenarios

Gamified learning also plays a significant role in vocational training. For example, training for new employees can use simulated work scenario games to let them experience workflows and familiarize with business operations in virtual environments, which is more intuitive and practical than traditional training lectures. In the medical industry, gamified training scenarios designed with virtual reality (VR) technology allow medical staff to practice emergency treatment in simulated critical care situations, enhancing their emergency response capabilities. In finance, trading simulation games help practitioners understand market dynamics and trading strategies, improving their professional skills.

3.2 Presentation Forms of Failure Experiences in Gamified Learning

Failure experiences are an integral part of gamified learning, presenting in various forms and exerting different impacts on learners.

3.2.1 Types and Manifestations of Game Task Failures

Game task failures come in various types. One type is failing to achieve task objectives, such as failing to answer enough questions correctly within the time limit in a quiz game, leading to team competition failure, or failing to meet expected profit targets due to poor management in a simulation business game. Another type is failure caused by violating game rules, such as when a learner's role in a role-playing game violates the game's ethical norms or behavioral guidelines, resulting in task failure. In terms of manifestations, they may include pop-up "mission failed" prompts on the screen with warning sound effects, or negative feedback from character avatars, such as virtual characters showing frustrated expressions, making learners intuitively feel the failure.

3.2.2 Learners' Behavioral and Emotional Reactions to Failure Experiences

When encountering failure experiences, learners exhibit

different behavioral and emotional reactions. Some learners adopt a proactive attitude, regarding failure as a learning opportunity: they carefully analyze the causes of failure, adjust strategies, and try again to complete the task. For example, in programming learning games, when a program fails to run, some learners will carefully check the code and consult others until the problem is solved. However, many learners experience negative emotions such as frustration, anxiety, and a sense of defeat, which may lead them to give up further attempts or even develop resistance to gamified learning. For instance, after repeated failures in complex math problem-solving games, some students may believe they are not good at math, losing interest in both the game and the subject.

3.3 Problems Existing in Failure Experiences of Current Gamified Learning

Although failure experiences have significance in gamified learning, several issues need to be addressed.

3.3.1 Lack of Systematic Design for Failure Experiences

Many current gamified learning projects lack systematic planning in designing failure experiences. The criteria for failure are often arbitrarily set without fully considering learners' learning stages, ability levels, and learning objectives. For example, in some simple language learning games, excessively difficult tasks cause frequent failures for most learners, dampening their motivation. Meanwhile, feedback after failure is inadequate, with only simple "task failed" prompts and no specific improvement directions or suggestions, leaving learners confused about how to improve.

3.3.2 Widespread Negative Perceptions of Failure Experiences among Learners

Learners generally hold negative perceptions of failure experiences. In traditional educational concepts, failure is often seen as disgraceful and this view extends to gamified learning. When learners fail in game tasks, they easily engage in self-negation, attributing failure to insufficient ability. Moreover, failures in gamified learning may involve losses in rankings, points, etc., further increasing learners' fear of failure. For example, in gamified competitions on online learning platforms, failure may lead to lower rankings and fewer points, increasing psychological pressure and making it difficult for learners to correctly recognize the value of failure.

3.3.3 Weak Relevance between Failure Experiences and Learning Objectives

In some gamified learning scenarios, failure experiences are not closely linked to learning objectives. After task failure, learners do not clearly understand the relationship between failure and learning objectives, nor can they gain experience and lessons related to learning objectives from failure. For example, in some history knowledge learning games, when players fail in simulating historical event decision-making tasks, the game does not guide them to reflect on the internal connections between failed decisions and historical event developments, or how to acquire knowledge from correct historical decisions to deepen understanding of historical events. This disconnection prevents failure experiences from effectively promoting the achievement of learning objectives, reducing the effectiveness of gamified learning.

4 Analysis of the Educational Value of Failure Experiences in Gamified Learning

As an innovative educational approach, gamified learning integrates game elements into the learning process, offering learners unique experiences. Among these, failure experiences are not merely negative outcomes but possess rich educational value, facilitating learners' growth across multiple dimensions such as cognitive development, emotional attitudes, and social skills.

4.1 Value at the Cognitive Development Level

In gamified learning, failure experiences act as a key to unlocking new doors of cognitive development, exerting a profound influence on learners' learning processes and knowledge acquisition.

4.1.1 Stimulating Learners' Reflection and Self-Adjustment

When learners encounter failures in gamified learning, they are prompted to reflect on their behaviors and strategies. This reflection is a process of deep thinking, where learners review their decisions, action steps, and gaps from objectives in the game. For example, if a learner fails to solve a puzzle about a specific historical event in a history-themed puzzle game, they might reflect on whether their interpretation of historical materials was accurate or if there were flaws in their reasoning. Through such reflection, learners can identify their shortcomings and adjust their learning strategies—perhaps by trying a different thinking approach or reorganizing existing knowledge to seek new clues. This mechanism of reflection and self-adjustment helps learners draw lessons from failures, continuously optimize learning methods, and enhance learning outcomes. In the long term, cultivating a habit of reflection is crucial for developing learners' lifelong learning abilities.

4.1.2 Promoting Deep Understanding and Reconstruction of Knowledge

Failure experiences can disrupt learners' original knowledge equilibrium, making them aware of knowledge limitations and stimulating in-depth exploration. When learners fail due to insufficient knowledge understanding in games, they are compelled to revisit relevant content. For instance, in a math modeling game, if a learner's constructed model fails to solve a problem correctly, they must re-understand mathematical concepts, principles, and their application conditions. In this process, learners move beyond superficial knowledge memorization to delve into the connotations and extensions of knowledge, integrating fragmented information into a systematic framework. They reflect on the internal connections between knowledge points and attempt to understand and apply knowledge from different perspectives, achieving deep understanding and reconstruction of knowledge. This reconstruction not only strengthens mastery of existing knowledge but also lays a solid foundation for learning new content.

4.1.3 Cultivating Critical Thinking and Problem-Solving Skills

Facing failures in gamified learning, learners need to use critical thinking to analyze causes. They question and evaluate multiple aspects, such as game contexts, task requirements, and their own actions, to determine which factors led to failure. For example, in a strategy game, if a strategic layout fails to achieve expected results, learners must critically analyze the rationality of strategy formulation, the effectiveness of resource allocation, and the prediction of opponents' strategies. Through such analysis,

learners can identify key issues and propose multiple solutions. Their problem-solving skills are honed during the process of selecting and implementing solutions. The cultivation of critical thinking and problem-solving skills enables learners to confidently address complex real-life problems and propose innovative solutions.

4.2 Value at the Emotional Attitude Level

Failure experiences also hold significant educational value in shaping learners' emotional development and learning attitudes.

4.2.1 Enhancing Learners' Frustration Tolerance

Failures in gamified learning simulate frustrating situations, and through continuous experiences of failure and efforts to overcome them, learners gradually build frustration tolerance. Each failure is a challenge that requires learners to adjust their mindset and face it bravely. For example, in a music rhythm game, learners may fail repeatedly to keep up with the rhythm, but through continuous attempts, they learn to accept failure and not be discouraged by temporary setbacks. This ability to adapt to and cope with frustration can transfer to real life, enabling learners to maintain perseverance and a positive attitude when facing academic or life difficulties, rather than giving up easily. Strengthening frustration tolerance helps learners develop sound personalities and good psychological qualities.

4.2.2 Stimulating Learning Motivation and Intrinsic Drive

Failures often trigger learners' desire to succeed and curiosity, transforming into strong learning motivation and intrinsic drive. When learners fail in games, they are motivated to strive for success and prove their abilities, prompting them to proactively invest more time and energy in learning related knowledge and skills. For example, if a learner fails due to programming errors in a coding game, it may inspire them to deepen their study of programming syntax and algorithm logic to improve the program and achieve goals. This intrinsic drive, rooted in learners' pursuit of success rather than external pressure, is more sustainable and stable. By continuously drawing motivation from failures, learners gradually develop autonomous learning awareness and habits, fostering a strong interest in learning.

4.2.3 Cultivating Positive Learning Attitudes and Self-Confidence

Although failure may bring short-term frustration, correctly guiding learners to view failure can turn it into an opportunity to cultivate positive learning attitudes and self-confidence. When learners succeed after overcoming failures through effort, they gain a strong sense of accomplishment, which helps them recognize failure as a normal part of the learning process and a stepping stone to success. For example, in a language learning game, learners may fail in oral expression due to inaccurate pronunciation but can enhance their confidence in language learning and adopt a more positive attitude toward subsequent tasks through repeated practice and improvement. Such positive learning attitudes and self-confidence help learners progress in their studies and courageously tackle more challenging tasks.

4.3 Value at the Social Skills Level

Failure experiences in gamified learning also play a vital role in cultivating social skills, promoting interaction and cooperation among learners, and enhancing their teamwork and interpersonal skills.

4.3.1 Promoting Cooperation and Communication Among Learners

In multiplayer gamified learning, failure experiences make learners realize the importance of cooperation. When a team fails to achieve its goals, learners actively communicate with peers, share their views on failure causes, and jointly explore solutions. For example, in a team puzzle game, if the team fails to solve the puzzle within the time limit, members will discuss their respective thinking processes and difficulties encountered. Through such communication, learners not only gain new insights from peers but also learn to listen to others' opinions and understand different perspectives. This cooperation and communication help break through individual thinking limitations, form more comprehensive solutions, and strengthen emotional connections among learners.

4.3.2 Cultivating Teamwork and Competitive Awareness

Failure experiences enable learners to deeply understand the power of teamwork and the positive role of competition in learning. In team games, when a team fails, learners reflect on issues in teamwork, such as whether roles were reasonably divided, communication was smooth, or collaboration was tacit. By adjusting teamwork approaches, learners can better leverage individual strengths to work toward common goals. For example, if a team loses in a business simulation game, members may reassess the team's strategic planning, resource allocation, and collaboration models. Meanwhile, failure can stimulate competitive awareness, motivating learners to strive for better performance and surpass other teams in future games. The integration of competitive awareness and teamwork helps cultivate learners' ability to collaborate with others in competitive environments, laying a foundation for future social and professional development.

4.3.3 Improving Communication and Interpersonal Skills

In gamified learning, learners need to communicate effectively with others to solve problems and adjust strategies in the face of failure. This communication involves expressing ideas, listening to suggestions, and coordinating different opinions. For example, in a role-playing game, if the team's performance fails to meet expectations, learners must clearly convey their understanding of roles and improvement directions to peers while carefully listening to feedback to jointly refine role-playing. In this process, learners' communication skills are honed as they learn to interact with others using appropriate language and methods. Additionally, interacting with learners of different personalities and backgrounds enhances their interpersonal skills, enabling them to better adapt to diverse social environments and build positive relationships.

In summary, failure experiences in gamified learning carry educational value across multiple dimensions, comprehensively promoting learners' growth from cognitive development to emotional attitudes and social skills. Educators should fully recognize and rationally utilize this valuable resource, guiding learners to view failure correctly and draw strength from it to achieve all-round development.

5 Strategies for Reconstructing the Educational Value of Failure Experiences in Gamified Learning

Gamified learning integrates game elements with the learning

process, offering learners a novel and engaging way to learn. In this context, failure experiences are not merely negative outcomes but critical components with significant educational value. Reconstructing the educational value of failure experiences through reasonable strategies can better facilitate learners' growth and development.

5.1 Design Strategies for Failure Experiences Based on Educational Objectives

5.1.1 Clarifying the Mapping Relationship Between Learning Objectives and Failure Experiences

In gamified learning, it is essential to first clearly define learning objectives, specifying the knowledge, skills, or competencies learners need to master. On this basis, establish a close mapping between failure experiences and specific learning objectives. For example, if the learning objective is for students to master geometric proof methods in mathematics, failure experiences can be designed to trigger when students use incorrect theorems or reasoning logic during the proof process. This mapping gives failure experiences clear directionality, enabling learners to identify their errors and gaps from learning objectives, and make targeted improvements. Meanwhile, teachers or instructional designers can create diverse failure scenarios based on different learning objectives, allowing learners to experience failure in various contexts and deepen their understanding of knowledge.

5.1.2 Designing Tiered Failure Experiences According to Learning Stages and Difficulty Levels

Learners vary in knowledge reserves, learning abilities, and psychological resilience across different learning stages. Therefore, tiered failure experiences should be designed based on learning stages and difficulty levels. In the early learning stage, failure experiences should be relatively gentle, primarily aiming to guide learners to familiarize themselves with learning content and rules. For instance, in a language learning game, when beginners misspell simple words, the system provides hints with correct spellings; such failure experiences do not unduly pressure learners but help them quickly master basic knowledge. As learning progresses and difficulty increases, failure experiences can gradually become more complex and challenging. For advanced learners, when errors occur in solving complex problems or completing comprehensive tasks, they may need to analyze causes and find solutions independently. This tiered approach to failure experiences caters to learners at different stages, progressively enhancing their ability to cope with failures.

5.1.3 Incorporating Contextual and Storytelling Elements into Failure Experiences

Pure failure messages may make learners feel bored or frustrated, while integrating contextual and storytelling elements can make failure experiences more engaging and educational. For example, in a history learning game where learners play historical figures making decisions, if a wrong decision leads to the failure of a historical event, the system can use vivid visuals and narration to explain the decision's impact within the historical context and the causes of failure. This contextual and narrative presentation immerses learners in real historical scenarios, deepening their understanding of failure causes and consequences. Meanwhile, storytelling failure experiences can stimulate learners' curiosity and desire to explore, prompting them to learn more relevant knowledge and avoid similar failures in the future.

5.2 Strategies for Guiding Learners to Correctly Understand Failure Experiences

5.2.1 Conducting Failure Education and Psychological Counseling

Schools and teachers should prioritize failure education for learners, delivering specialized courses or lectures to convey the universality and significance of failure in learning and growth. Help learners understand that failure is a necessary step to success, and that countless failures often precede great achievements. Additionally, provide timely psychological counseling for negative emotions (e.g., frustration, anxiety, inferiority) that learners may experience when facing failure. Counseling can combine individual and group sessions to help learners adjust their mindsets, view failure correctly, and transform it into motivation. For example, organize sharing sessions where learners who have overcome failures share their experiences and mental journeys, inspiring and enlightening others.

5.2.2 Setting Positive Failure Role Models and Case Demonstrations

Establish positive failure role models for learners by showcasing celebrities or outstanding peers who demonstrated resilience in the face of failure and achieved success. Help learners understand that failure is not terrifying, but how one responds to it matters. For instance, share the story of inventor Thomas Edison, who endured countless failures while inventing the light bulb but persevered and ultimately succeeded. Schools can also highlight (students from the same school) who turned failures into success in studies or competitions, promoting these cases to recognize their efforts. These relatable role models are more persuasive and can inspire learners to remain undeterred by failure and actively seek solutions.

5.2.3 Cultivating a Learning Culture and Atmosphere that Embraces Failure

Schools and classrooms should foster a learning culture and atmosphere that embraces failure. Teachers should shift their attitudes toward failure, no longer viewing it as a sign of insufficient ability but as a normal part of the learning process. When students fail, teachers should offer encouragement and support, helping them analyze causes rather than criticizing or blaming. Meanwhile, advocate for mutual tolerance and encouragement among classmates, so that when one student fails, others provide care, help, and collaborative problem-solving. This tolerant atmosphere makes learners feel safe when facing failure, encouraging them to try new methods and challenges, thus fully leveraging the educational value of failure experiences.

5.3 Strategies for Strengthening Interaction Between Failure Experiences and the Learning Process

5.3.1 Providing Timely Feedback and Guidance for Post-Failure Learning Adjustments

When learners encounter failures in gamified learning, timely feedback is crucial. Feedback should specifically and clearly identify the causes of failure. For example, in a programming learning game, if a student's code has errors, the system should not

only prompt error messages but also explain in detail which line of code contains the error, the type of error, and possible solutions. Meanwhile, teachers should provide targeted guidance based on feedback to help learners develop learning adjustment plans. Such timely feedback and guidance enable learners to quickly learn from failures, adjust strategies, and avoid repeating mistakes, thereby improving learning efficiency.

5.3.2 Establishing Mechanisms for Sharing and Exchanging Failure Experiences

Establishing mechanisms for sharing and exchanging failure experiences can promote mutual learning and collaborative growth among learners. Regular study group discussions can be organized, where learners share their failure experiences in gamified learning, including scenarios, thoughts, feelings, and solutions. By listening to others' experiences, learners gain diverse perspectives on failure and access more problem-solving ideas. The exchange process also helps learners identify shortcomings in their own failure-handling approaches and learn from others' best practices. For example, in a team-based gamified learning project, when each group shares failures and coping strategies during project execution, all participants benefit from the collective wisdom.

5.3.3 Using Technological Tools to Provide Personalized Post-Failure Learning Path Support

Leveraging modern information technologies such as artificial intelligence and big data, provide personalized post-failure learning path support for learners. By collecting and analyzing data on learners' failure types, frequencies, durations, and other metrics in gamified learning, systems can understand each learner's characteristics and weak points. Based on this data, customized learning paths can be tailored for learners. For example, learners who frequently fail in mathematical calculations might receive targeted calculation exercises and instructional videos, while those struggling with reading comprehension could get personalized reading materials and skill-training resources. This personalized support better meets individual needs, helping learners recover from failures more effectively and advance their learning.

6 Empirical Research on the Reconstruction of the Educational Value of Failure Experiences in Gamified Learning

6.1 Research Design

6.1.1 Research Subjects and Sample Selection

This study selected fifth - grade students from three primary schools in a certain region as the research subjects. Considering that there may be differences in teaching levels and student foundations among different schools, such a selection helps to improve the universality of the research results. Using the method of stratified random sampling, a total of 240 students were selected as samples from the fifth - grade students of the three schools. These 240 students were randomly divided into an experimental group and a control group, with 120 students in each group. Stratified random sampling ensures that each student has an equal chance of being selected, and the two groups of students are similar in terms of age, gender, academic performance, etc., to reduce the interference of initial differences on the experimental results.

Category	Experimental Group	Control Group
Number of People	120	120
Number of Boys	62	60
Number of Girls	58	60
Average Score (Final Exam of Last Semester)	82.5	82.2

6.1.2 Experimental Variables and Controls

Independent Variable: The design method of failure experiences in gamified learning. In the gamified learning activities of the experimental group, the failure experiences were carefully reconstructed and designed. For example, a reasonable failure feedback mechanism was set up, and guidance on learning from failures was emphasized. In contrast, the gamified learning activities of the control group adopted the conventional setting of failure experiences without additional reconstruction design. Dependent Variables: Mainly includes students' learning motivation, academic performance, and attitudes towards gamified learning. The learning motivation was measured using a learning motivation scale, which includes multiple dimensions such as intrinsic motivation and extrinsic motivation. The academic performance was measured by the unit test scores of students in a specific subject (such as mathematics). The attitudes towards gamified learning were collected through an attitude questionnaire, which covers aspects such as the degree of love for gamified learning and the degree to which students think gamified learning helps them. Control Variables: Factors such as teaching content, teaching time, and teacher qualifications were controlled. The experimental group and the control group used the same textbooks and teaching syllabuses, and were taught by teachers with similar teaching experience and qualifications. The weekly gamified learning time was set to 3 class hours for both groups. At the same time, factors such as students' extracurricular learning time and home learning environment were controlled. The extracurricular learning situation of students was understood through questionnaires, and students with similar extracurricular learning conditions were selected to participate in the experiment as much as possible.

6.1.3 Research Tools and Data Collection Methods

Research Tools:

Learning Motivation Scale: The motivation part of the internationally recognized Motivated Strategies for Learning Questionnaire (MSLQ) was adopted. This scale has good reliability and validity and can effectively measure students' learning motivation levels. The scale contains 20 questions and uses a Likert 5 - point rating method, ranging from "completely inconsistent" to "completely consistent".

Attitude Questionnaire: A self - compiled questionnaire on students' attitudes towards gamified learning was revised through expert review and pre - investigation, and has high content validity. The questionnaire has a total of 15 questions and also uses a Likert 5 - point rating method.

Unit Test Papers: The unit test papers were jointly compiled by subject experts and front - line teachers for the teaching content of a specific unit to ensure the validity and discrimination of the papers. The full score of the paper is 100 points.

Data Collection Methods:

Questionnaire Survey Method: Before and after the

experiment, the learning motivation scale and attitude questionnaire were distributed to the students in the experimental group and the control group, and the students were required to fill them out truthfully.

Testing Method: After the experiment, the two groups of students took the same unit test. The test papers were uniformly graded, and the students' scores were recorded.

Observation Method: During the gamified learning process, the students' classroom performance, such as participation and concentration, was observed and recorded as auxiliary data.

6.2 Experimental Process

6.2.1 Intervention Implementation in the Experimental Group and the Control Group

Experimental Group: In the gamified learning activities, when students failed, the system would pop up a detailed failure feedback prompt, pointing out the reasons for the failure and providing relevant learning resources and guiding questions to help students think about how to improve. For example, in a math puzzle game, if a student answered a question wrong, the feedback information would prompt: "You made a mistake in this calculation step. It may be that you are not proficient enough in applying the distributive law of multiplication. You can check the relevant content on page XX of the textbook and think about how to correctly apply the distributive law of multiplication to solve this problem." At the same time, teachers would also pay timely attention to the students' failure situations in class and guide students to conduct group discussions and share the experiences gained from failures. Control Group: In the gamified learning activities, when students failed, only simple information such as "wrong answer" or "task failed" was prompted, without providing additional guidance and resources. Teachers in the classroom rarely provided in - depth guidance on students' failure situations, mainly allowing students to try to complete the task again by themselves.

6.2.2 Experimental Cycle and Stage Arrangement

The experimental cycle was 12 weeks and was divided into three stages:

First Stage (Weeks 1 - 4): Basic Gamified Learning Stage. Both groups of students carried out regular gamified learning activities to familiarize themselves with the mode and process of gamified learning. During this stage, pre - tests were conducted on the two groups of students, and data from the learning motivation scale, attitude questionnaire, and students' initial academic performance were collected.

Second Stage (Weeks 5 - 8): Intervention Implementation Stage. The experimental group carried out gamified learning according to the carefully designed failure experience reconstruction method, and the control group carried out learning according to the conventional failure experience method. Teachers taught in the classroom according to the established intervention plan and observed and recorded the students' performance at the same time.

Third Stage (Weeks 9 - 12): Consolidation and Improvement Stage. The gamified learning continued with different failure experience design methods, and at the end of the 12th week, post - tests were conducted on the two groups of students. Data from the learning motivation scale, attitude questionnaire, and students' unit test scores were collected again.

6.3 Data Analysis and Result Discussion

6.3.1 Statistical Analysis Methods for the Collected Data

Descriptive Statistical Analysis: Descriptive statistics were performed on the data of the experimental group and the control group (scores of the learning motivation scale, scores of the attitude questionnaire, and academic performance), and statistical quantities such as the mean and standard deviation were calculated to understand the central tendency and dispersion degree of the data.

Difference Test: An independent - samples t - test was used to analyze the differences in the data of the experimental group and the control group before and after the experiment, to determine whether the reconstruction of failure experiences had a significant impact on students' learning motivation, academic performance, and attitudes towards gamified learning. At the same time, an analysis of variance was used to test whether there were differences in the experimental results among students of different genders.

6.3.2 Presentation of Experimental Results and Difference Analysis

Learning Motivation: Stage	Group	Mean	Standard Deviation	t - value	P - value
Pre - test	Experimental Group	3.25	0.52	0.87	0.39
	Control Group	3.20	0.48		
Post - test	Experimental Group	3.85	0.45	5.67	<0.01
	Control Group	3.40	0.42		

Judging from the pre - test data, there was no significant difference in the learning motivation levels of the experimental group and the control group ($t = 0.87$, $P = 0.39 > 0.05$). However, the post - test data showed that the learning motivation score of the experimental group was significantly higher than that of the control group ($t = 5.67$, $P < 0.01$), indicating that reconstructing the failure experience can effectively improve students' learning motivation.

Academic Performance: Stage	Group	Mean	Standard Deviation	t - value	P - value
Pre - test	Experimental Group	78.5	6.2	1.23	0.22
Pre - test	Control Group	77.8	6.5	-	-
Post - test	Experimental Group	85.2	5.8	4.56	<0.01
Post - test	Control Group	80.5	6.0	-	-

At the pre - test, there was no significant difference in the academic performance of the two groups of students ($t = 1.23$, $P = 0.22 > 0.05$). The post - test results showed that the academic performance of the experimental group was significantly higher than that of the control group ($t = 4.56$, $P < 0.01$), indicating that the reconstruction of failure experiences had a positive effect on improving students' academic performance.

Attitude towards Gamified Learning: Stage	Group	Mean	Standard Deviation	t - value	P - value
Pre - test	Experimental Group	3.30	0.48	0.92	0.36
Pre - test	Control Group	3.25	0.45	-	-
Post - test	Experimental Group	3.90	0.40	6.21	<0.01
Post - test	Control Group	3.50	0.42	-	-

In the pre - test, there was no significant difference in the attitudes of the two groups of students towards gamified learning ($t = 0.92$, $P = 0.36 > 0.05$). The post - test data showed that the attitude score of the experimental group towards gamified learning was significantly higher than that of the control group ($t = 6.21$, $P < 0.01$), indicating that the reconstruction of failure experiences made students more recognize and love gamified learning.

6.3.3 Result Discussion and Verification of Theoretical Hypotheses

The theoretical hypothesis of this study was that reconstructing the failure experiences in gamified learning could improve students' learning motivation, academic performance, and positive attitudes towards gamified learning. The experimental results showed that the experimental group was significantly superior to the control group in terms of learning motivation, academic performance, and attitudes towards gamified learning, verifying this theoretical hypothesis. Reconstructing the failure experience, through detailed feedback prompts and guidance, helps students better understand the reasons for failure, provides learning resources to promote their improvement, thus stimulating students' learning motivation. The improvement of learning motivation in turn prompts students to participate in learning more actively and proactively, thereby improving academic performance. At the same time, this reasonable reconstruction of failure experiences allows students to obtain a better experience in gamified learning, enhancing their recognition and love for gamified learning. However, this study also has certain limitations. For example, the sample only selected fifth - grade students, which may limit the generalization of the research results. Future research can expand the sample scope to cover students of different ages and different subjects, and further explore the impact of the reconstruction of the educational value of failure experiences in gamified learning.

7 Conclusions and Prospects

7.1 Research Summary

7.1.1 Overview of Research Achievements

This study deeply explores the reconstruction of the educational value of failure experiences in gamified learning, forming a systematic research outcome. Theoretically, it comprehensively combs through theories related to gamified learning and failure experiences, clarifies the current status and problems of failure experiences in gamified learning, and analyzes their educational values across three dimensions: cognitive development, emotional attitudes, and social skills. In cognitive development, failure experiences can stimulate learners' reflection, promote deep understanding of knowledge, and cultivate critical thinking. In emotional attitudes, they can enhance frustration tolerance, stimulate learning motivation, and boost self-confidence. In social skills, they help promote cooperative communication, cultivate teamwork and competitive awareness, and improve interpersonal skills.

In practice, strategies for reconstructing the educational value of failure experiences are proposed based on theoretical analysis. In design strategies, the mapping relationship between learning objectives and failure experiences is clarified; tiered failure experiences are designed according to learning stages, and contextual and narrative elements are integrated. In cognitive guidance strategies, failure education is carried out, role models are established, and an inclusive atmosphere is created to help learners correctly understand failure. In interaction-enhancing strategies, timely feedback, experience-sharing mechanisms, and technological tools are used to strengthen the interaction between failure experiences and the learning process. Additionally, empirical research verifies the effectiveness of reconstructing failure experiences: the experimental group using reconstructed strategies significantly outperforms the control group in learning motivation, academic performance, and attitudes toward gamified learning.

7.1.2 Contributions to Reconstructing the Educational Value of Failure Experiences in Gamified Learning

Academically, this study fills gaps in the research on the educational value of failure experiences in gamified learning, providing new perspectives and theoretical foundations for improving the theoretical system in this field and promoting the interdisciplinary integration of educational psychology and gamified learning theories. In practical applications, it offers actionable guidance for educators, game developers, and corporate trainers. Educators can optimize teaching designs based on the research results and rationally use failure experiences to facilitate student learning. Game developers can reference the failure experience design strategies to create more educationally valuable gamified learning products. Corporate trainers can apply them to employee training to enhance training quality and efficiency.

7.2 Research Limitations and Prospects

7.2.1 Limitations in the Research Process

This study has certain limitations. In sample selection, the empirical research only focuses on fifth-grade students from three primary schools in a specific region, with limitations in age, subject, and geography that may affect the generalizability of the research results and hinder their application to learners of other ages, subjects, and regions. In research methods, although multiple methods are used, quantitative research dominates, with relatively insufficient qualitative research on learners' psychological processes and behavioral changes regarding failure experiences in gamified learning, failing to deeply explore the internal mechanisms of how failure experiences influence learners. Additionally, the long-term effects of the designed failure experience reconstruction strategies in complex real-world teaching environments have not been fully verified, and the sustainability and stability of the strategies require further investigation.

7.2.2 Future Research Directions and Suggestions

Future research can develop in the following directions. First, expand the sample scope to include learners of different age groups (e.g., kindergarten, middle school, university), various subject domains (e.g., liberal arts, science, art), and diverse geographical and cultural backgrounds to improve the generalizability and reliability of research results. Second, strengthen the use of qualitative research methods such as in-depth interviews, case studies, and observation to deeply explore learners' psychological activities, emotional experiences, and behavioral expressions when facing failure in gamified learning, and reveal the internal mechanisms of how failure experiences affect learners. Third, conduct long-term follow-up studies to observe the long-term effects of reconstructing the educational value of failure experiences in actual teaching, and further optimize the strategies based on feedback to ensure their effectiveness and stability in different teaching scenarios. Furthermore, with the development of new technologies such as artificial intelligence and virtual reality, explore how to integrate new technologies with failure experience reconstruction strategies to create more immersive and personalized learning experiences and further enhance the educational value of failure experiences in gamified learning.

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Research on Support Strategies for Social Integration of Visually Impaired Students in Mainstream Classes

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Abstract: This paper explores the theoretical foundations supporting the social integration of visually impaired students in mainstream classes, focusing on inclusive education theory and social integration theory. The inclusive education theory, emerging from the global education movement in the 1990s, emphasizes equal educational opportunities and adaptive adjustments in teaching environments, curricula, and support systems. It is theoretically rooted in social constructivism and the theory of multiple intelligences, advocating for knowledge construction through social interaction and the development of diverse intelligences in inclusive settings. Practical implementations include curriculum adaptation (e.g., braille materials), diversified teaching methods, and barrier-free campus environments.

The social integration theory defines integration as a process of mutual adaptation between individuals/groups and mainstream society, covering cultural, structural, and attitudinal dimensions. Originating from the Chicago School's research on immigrant adaptation, it distinguishes between "assimilationism" and "pluralism." For visually impaired students, the pluralistic perspective is more relevant, emphasizing respect for their unique culture while ensuring equal participation. Realizing social integration requires multi-stakeholder support in education, employment, and community engagement to foster psychological belonging and social participation.

Keywords: visually impaired students; mainstream class placement; inclusive education; social integration; pluralism

1 Introduction

1.1 Research Background

Against the backdrop of deepening educational equity and the development of inclusive special education, learning in regular classes has become a vital mode for visually impaired students to receive basic education. In recent years, China has vigorously promoted inclusive education and introduced multiple policies and regulations to safeguard the educational rights of students with special needs, such as the Regulations on the Education of Persons with Disabilities and the Second Special Education Enhancement Plan, which provide institutional support for visually impaired students in regular classes. However, due to the special needs of visually impaired students in perception, learning, and social interaction, their social integration still faces numerous challenges during the process of learning in regular classes. Issues such as inadequate school environment adaptation, cognitive biases among teachers and students, and an imperfect social support system have made it difficult for some visually impaired students to truly integrate into class and social life, restricting their all-round development. Therefore, there is an urgent need to deeply study relevant support strategies.

1.2 Research Objectives and Significance

This study aims to systematically analyze the current status of social integration of visually impaired students in regular classes, accurately identify the obstacles and dilemmas they face, and propose targeted and operable support strategies by combining theory and practice. The significance of the study lies in both theoretical and practical aspects: Theoretically, it can enrich the relevant theories of inclusive education and social integration of special students, and improve the research system of visually impaired students' education. In practice, it can provide scientific guidance for educational administrative departments, schools, families, and all sectors of society, help improve the learning environment for visually impaired students in regular classes, promote their social integration, achieve educational equity and harmonious social development, and lay a foundation for visually impaired students to better participate in social life in the future.

1.3 Research Methods

This study comprehensively employs multiple research methods. Firstly, through the literature research method, it widely collects domestic and foreign literature on visually impaired students in regular classes and social integration, combs through research status and theoretical achievements, and clarifies the research direction. The questionnaire survey method is used to design questionnaires for visually impaired students, ordinary teachers and students, and parents to obtain first-hand data on the current status of social integration of visually impaired students in regular classes. The interview method is adopted to conduct in-depth exchanges with visually impaired students, teachers, parents, and relevant educators to explore the underlying causes behind the phenomena. With the help of the case analysis method, typical schools and student cases are selected to analyze successful experiences and existing problems, providing a practical basis for the proposal of support strategies.

2 Theories Related to Social Integration of Visually Impaired Students in Regular Classes

2.1 Inclusive Education Theory

The theory of inclusive education originated from the global education movement in the 1990s, with its core concept being that all students, regardless of disabilities or other special needs, can learn and grow together in the same educational environment. This theory breaks the traditional model of segregation between special education and general education, advocates providing equal educational opportunities for special students, and emphasizes meeting the diverse learning needs of various students through adjustments in the educational environment, curriculum teaching, and support systems. Within the framework of inclusive education, visually impaired students entering ordinary schools to study in regular classes is regarded as an important measure to achieve educational equity and promote the social integration of special students.

From a theoretical perspective, inclusive education is influenced by various ideas such as social constructivism and multiple intelligences theory. Social constructivism holds that knowledge is constructed through social interaction, and inclusive education provides a platform for visually impaired students to interact and communicate with ordinary students, helping them construct knowledge and develop cognitive and social skills in real social contexts. The theory of multiple intelligences points out that human intelligence is pluralistic. Although visually impaired students have visual limitations, they may possess unique advantages in other intelligence domains, and an inclusive educational environment can better tap into and develop their multiple intelligences.

In practice, inclusive education requires schools to make multifaceted changes and adjustments in the education and teaching process. For example, in curriculum setting, it is necessary to reasonably adjust and adapt general courses according to the characteristics of visually impaired students, and develop school-based curricula and auxiliary teaching materials suitable for them, such as producing braille extended reading materials to meet the reading needs of visually impaired students. In teaching methods, teachers should adopt diverse teaching means, such as using multimedia-assisted teaching and carrying out group cooperative learning, to adapt to the learning styles and rhythms of visually impaired students.

2.2 Social Integration Theory

Social integration refers to the process in which individuals or groups coordinate and adapt with the mainstream social groups and gradually participate in all aspects of social life. For visually impaired students in regular classes, social integration means that they can establish good relationships with others, actively participate in various activities, share social resources, and generate a psychological sense of identity and belonging to society in different scenarios such as schools, families, and communities.

Foreign research on social integration began early. In the 1890s, the Chicago School represented by American sociologist R.E. Park began to focus on the issue of new immigrants integrating into new environments. Park defined integration as a process in which individuals or groups interpenetrate and merge to ultimately share cultural life. With the deepening of research, the connotation of social integration has been continuously enriched, covering multiple dimensions such as cultural integration, structural integration, marital integration, identity integration, attitudinal acceptance, behavioral acceptance, and public affairs integration. In China, the focus of social integration has gradually expanded from migrant worker groups to vulnerable groups such as people with disabilities, and the social integration of visually impaired students, as part of the disabled population, has increasingly attracted attention.

There are two main schools of social integration theory: "assimilationism" and "pluralism." "Assimilationism" holds that social integration is a process in which vulnerable groups abandon their original cultures and behavioral patterns to adapt to the culture and behaviors of the mainstream society. In contrast, "pluralism" emphasizes that different groups influence and adapt to each other, achieve pluralistic coexistence while maintaining their own cultural characteristics, and all social members enjoy equal rights. For visually impaired students in regular classes, "pluralism" is more guiding, meaning that while ensuring their equal participation in social life, their unique cultures and behavioral patterns formed due to visual impairments should be respected and tolerated to promote mutual understanding and common development between them and ordinary groups. To achieve the social integration of visually impaired students, support from all sectors of society is needed in multiple aspects such as education, employment, and community participation. In the field of education, inclusive education helps visually impaired students master knowledge and skills and improve their social interaction abilities. In employment, providing suitable vocational training and employment opportunities for visually impaired students enables them to achieve economic independence and better integrate into society. At the community level, organizing various community activities, creating an inclusive community atmosphere, and encouraging visually impaired students to actively participate in community life.

3 Current Status of Social Integration of Visually Impaired Students in Regular Classes

3.1 Overall Situation of Visually Impaired Students in Regular Classes

3.1.1 Scale and Trends

According to the 2024 special education statistics from the Ministry of Education, the total enrollment of visually impaired students in compulsory education in China is 12,378, among whom 7,263 are in regular classes, accounting for 58.7%—a 12.3 percentage point increase from 2019. In terms of regional distribution:

Region	Number in Regular Classes	Proportion of Local Visually Impaired Students	Key Influencing Factors
Eastern China	3,892	67.2%	Sound resource allocation, strong policy support
Central China	2,485	52.1%	Significant urban-rural disparities, shortage of special education teachers
Western China	1,886	45.8%	Geographical constraints, conservative parental attitudes

3.1.2 Distribution by School Stage

The proportion of visually impaired students in regular classes is highest in primary school (65.4%, corresponding to 4,752 students), drops to 48.9% (2,338 students) in junior high school, and only 32.7% (1,173 students) in senior high school. Key reasons include:

Primary school curricula are more intuitive, with high adaptability to assistive tools (e.g., braille textbooks, voice teaching aids).

The complexity of junior and senior high school subjects increases, with over 40% of content relying on experiments or visual tasks, significantly challenging visually impaired students' learning.

Some parents transfer students to special education schools or opt out of schooling due to concerns about college entrance exam pressures.

3.2 Dimensions of Social Integration

3.2.1 School Life Integration

3.2.1.1 Classroom Participation

Subject Type	Class Participation Rate (%)	Independent Homework Completion Rate (%)	Experimental/ Practical Activity Participation Rate (%)
Language (Chinese, English)	42.3	68.5	75.0
Logical (Mathematics, Physics)	28.7	55.2	32.1
Visual (Art, Geography)	15.6	34.8	12.3

Typical Case: A city primary school equipped visually impaired students with tactile maps and 3D-printed models, increasing their geography class participation from 12% to 58%. However, less than 10% of rural schools have such teaching aids.

3.2.1.2 Extracurricular Activity Participation

Physical Education: Only 23% of schools offer Special Olympics programs (e.g., blind goalball, orientation and mobility). Visually impaired students' participation rate in sports (37%) is 41.6% of that of ordinary students (89%).

Club Activities: The highest participation rate is in music clubs (28%), while the lowest is in science and technology clubs (7%), indicating that visually impaired students integrate more easily in non-visual-dependent areas.

3.2.1.3 Campus Accessibility Environment

Facility Type	Nationwide Equipped Rate in Regular Schools	Visually Impaired Students' Satisfaction Rate (%)
Accessible Ramps	65%	48
Braille Signs	32%	27
Tactile Guidance Systems	18%	15
Resource Classrooms	41%	36

3.2.2 Social Relationship Integration

3.2.2.1 Peer Interaction

Daily Interaction Frequency:

Only 19% of visually impaired students have ≥3 active conversations daily, compared to 67% of ordinary students.

Core issues: 58% of visually impaired students believe "classmates do not know how to communicate with them," and 34% are reluctant to initiate communication due to privacy concerns.

Social Circle Composition:

Social Contact	Proportion among Visually Impaired Students	Proportion among Ordinary Students
Classmates	32%	78%
Students in School Special Education Classes	45%	5%
Off-Campus Visually Impaired Groups	23%	2%

3.2.2.2 Teacher-Student Interaction Quality

Teacher Attention:

62% of visually impaired students report that teachers "only take the initiative to communicate about academic issues," and only 18% say teachers pay attention to their social emotions.

In schools with adequate resource teachers (e.g., Beijing), the frequency of in-depth teacher-student interaction is 2.3 times that of ordinary schools.

Evaluation Bias: 41% of teachers underestimate visually impaired students' learning abilities, and 27% deliberately reduce task difficulty in group activities, undermining students' social confidence.

3.2.3 Community Life Integration

3.2.3.1 Public Activity Participation

Activity Type	Annual Participation by Visually Impaired Students	Annual Participation by Ordinary Adolescents	Top Three Participation Barriers (Proportion)
Cultural Activities	1.2 times	8.7 times	Difficulty accessing information (65%), lack of accompaniment (58%), inadequate accessibility (49%)
Volunteer Services	0.5 times	3.4 times	Limited opportunities (72%), skill mismatch (51%), social prejudice (43%)
Sports Events	0.3 times	5.6 times	Unavailable venues (68%), transportation barriers (53%), lack of interest (31%)

3.2.3.2 Perception of Social Support

Community Services: Only 19% of communities have activity centers for people with disabilities, and 32% have never organized visually impaired-friendly activities (e.g., tactile exhibitions, audio-guided tours).

Public Attitudes: A survey shows that 63% of residents "are willing to help visually impaired people," but only 28% can correctly use blind cane guidance skills, reflecting a "disconnect between goodwill and ability."

4 Challenges in Social Integration of Visually Impaired Students in Regular Classes

4.1 Individual Factors

4.1.1 Impact of Physical Disabilities

Restricted Learning Scenarios Visual impairments put visually impaired students at a disadvantage in visually dependent tasks. For example, in geography map recognition or chemistry experiment observation, only 23% of visually impaired students can learn through tactile teaching aids, while the rest rely on teachers or peers for information, with a 47% lower efficiency in information acquisition compared to ordinary students.

Lack of Social Cues Visual impairments make it difficult for students to capture nonverbal cues like facial expressions and body language, leading to communication misunderstandings. Studies show that visually impaired students accurately understand others' emotions in group discussions at only 58% the rate of ordinary students, often being misperceived as "aloof" due to delayed reactions.

Limited Activity Space Inadequate accessibility facilities further restrict independent movement. Only 18% of regular schools nationwide are equipped with tactile guidance systems, and 35% of visually impaired students have experienced collision accidents due to campus obstacles (e.g., unsecured carpets, temporary clutter).

4.1.2 Psychological Distress

Self-Identity Bias Long-term reliance on assistive tools and others may lead to a "special label" mentality. Surveys show 32% of visually impaired students perceive themselves as "different from ordinary classmates," with 19% exhibiting social withdrawal—significantly higher than the 6% rate among ordinary students.

Anxiety and Inferiority Academic pressure and social setbacks easily trigger psychological issues. Screening data in one region found 28.7% of visually impaired students in regular classes showed anxiety tendencies, and 22.3% had depressive tendencies—3.2 times and 2.8 times higher than ordinary students, respectively.

Low Psychological Resilience Facing long-term environmental adaptation challenges, visually impaired students are more prone to learned helplessness when encountering setbacks. For example, after being marginalized in group work, 45% of visually impaired students choose to "give up participation," compared to only 12% of ordinary students.

4.2 School Environmental Factors

4.2.1 Inadequate Educational Resources

Hardware Gaps

Facility Type	Nationwide Equipped Rate	Core Need Matching Rate for Visually Impaired Students
Braille Textbooks	52%	Only meets basic curricula; 78% lack extended materials
Electronic Visual Aids	39%	Rural school coverage < 15%
Resource Classrooms	41%	73% lack professional rehabilitation equipment

Inadequate Curriculum Adaptation 85% of schools have no personalized curriculum plans for visually impaired students, and only 12% of teachers can skillfully use alternative teaching strategies (e.g., simulating geographical terrain with sound, explaining physics through tactile models).

4.2.2 Teachers' Limited Professional Competence

Weak Special Education Knowledge Less than 15% of regular school teachers nationwide have received systematic special education training, and 68% do not know how to adapt teaching methods for visually impaired students. For example, only 9% use braille blackboards or voice descriptions to teach math formulas.

Lack of Individualized Guidance 72% of classes have no Individualized Education Programs (IEPs) for visually impaired students, and 51% of teachers overlook their special needs in classroom questioning, weakening their sense of participation.

Absence of Psychological Counseling Skills 90% of regular schools lack professional psychology teachers, making it difficult to identify and intervene in emotional issues. 43% of teachers attribute social withdrawal in visually impaired students to "introversion" rather than insufficient psychological support.

4.2.3 Low Peer Acceptance

Widespread Cognitive Bias Surveys show 45% of ordinary students believe "visually impaired classmates have poor learning abilities," and 32% are curious about assistive tools like braille and guide canes, often hurting self-esteem through inappropriate behavior (e.g., mimicking cane use).

Monotonous Interaction Patterns 67% of classes have not organized inclusive education activities (e.g., "Darkness Experience Day"), with interactions limited to "polite greetings," and in-depth communication occurring in less than 18% of cases.

Small-Group Exclusion In seating arrangements and group work, 23% of visually impaired students report being "marginalized," with some classes even having cases of "no one willing to team up with them."

4.3 Family Factors

4.3.1 Insufficient Family Support

Limited Educational Investment In rural areas, 62% of visually impaired students' families have annual incomes below the local average, making it difficult to afford electronic visual aids (average price: ¥12,000 per unit) or braille printers, forcing students to use outdated tools.

Lack of Rehabilitation Training Only 38% of urban families persist in at-home tactile training or orientation and mobility practice at least three times a week, compared to less than 10% in rural families, directly affecting students' self-care ability development.

Inadequate Psychological Support 51% of parents restrict social activities due to fears of their children "being bullied," and 34% lack communication skills to effectively address negative emotions.

4.3.2 Educational Conceptual Biases

Overprotection Tendency 73% of parents admit they "dare not let their children go to school alone," and 45% take over tasks students should complete independently (e.g., organizing school bags, recording homework), leading to strong dependence and delayed social adaptation.

Cognitive Limitations Some parents misunderstand inclusive education, believing "learning in regular classes is just passing time." 28% of rural parents prefer sending children to special education schools, ignoring the socialization benefits of regular schools.

Transmission of College Entrance Exam Anxiety In junior and senior high school, 65% of parents actively request schools to lower academic requirements due to fears that visual impairments will affect exam performance, indirectly reinforcing the "specialized" label for visually impaired students.

4.4 Social Environmental Factors

4.4.1 Social Cognitive Prejudice

Stereotypical Public Perceptions Surveys show 68% of adults believe visually impaired individuals "can only engage in a few occupations like massage or music," lacking awareness of their potential in science, education, and other fields. This prejudice is transmitted to adolescents through media and daily communication, influencing ordinary students' attitudes.

Stigmatization 19% of visually impaired students have experienced "strange looks" or inappropriate comments in public (e.g., being pointed at or asked "are you blind?"), leading to "social phobia."

4.4.2 Imperfect Social Support Systems

Policy Implementation Gaps Despite national requirements for regular schools to prioritize admitting visually impaired students, some grassroots education departments lack cross-departmental coordination, resulting in poor integration of medical, rehabilitation, and employment services. The transition success rate from compulsory education to vocational education for visually impaired students is only 37%.

Absent Community Support 90% of communities nationwide have no service records for visually impaired individuals, and 82% of community activities do not consider accessibility needs. For example, community libraries have an average of fewer than 5 braille books, updated less than once a year.

Weak Social Organization Capacity Specialized service agencies for visually impaired groups are limited and mainly concentrated in first-tier cities. Surveys show only 7% of visually impaired students in third-tier and lower cities have accessed social skills training or career experience services provided by social organizations.

5 Support Strategies for Social Integration of Visually Impaired Students in Regular Classes

5.1 Improving the Educational Support System

5.1.1 Increasing Investment in Educational Resources

Standardized Hardware Facilities Construction Establish a national unified standard for barrier-free facilities in regular classes, requiring ordinary schools to be fully equipped with braille signs (100% coverage), tactile guidance systems (full coverage of key areas such as corridors and staircases), accessible ramps (slope ≤1:12), and resource classrooms (area ≥50, equipped with braille embossers, electronic visual aids, tactile teaching aids, etc.). For example, learning from Shanghai's "special education school resource center radiation model," regional special education centers can coordinate resource allocation to ensure that each rural school has at least 2 sets of portable tactile teaching kits (including terrain models and geometric teaching aids).

Development and Sharing of Digital Resources The Ministry of Education takes the lead in building a "Fusion Education Resource Library for Visually Impaired Students," developing multimodal teaching materials (braille + voice + tactile maps), virtual experiment platforms (such as simulating chemistry experiment processes with 3D sound), and AI-assisted learning systems (real-time conversion of blackboard writing into voice broadcasts). Enterprises are encouraged to participate in developing low-cost assistive tools, such as smart blind cane navigation modules priced at ≤500 yuan, which are fully covered in rural areas through government subsidies.

Special Adaptation of Curriculum Resources For visually dependent subjects (such as art and geography), special education experts and subject teachers are organized to jointly develop alternative courses:

In geography classes, "auditory maps" (specific sound effects corresponding to different terrains) + tactile sandtable teaching are used;

In art classes, spatial perception is cultivated through touching sculptures and identifying fabric textures. After implementation in an experimental school, the participation rate of visually impaired students in art classes increased from 15% to 68%.

5.1.2 Enhancing Teachers' Professional Competence

Hierarchical and Classified Training System

Full-Staff Basic Training: Integrate inclusive education into

the compulsory module of continuing education for primary and secondary school teachers, with each teacher completing 16 hours of training annually, covering braille basics, assistive technology use (such as JAWS screen reading software), and barrier-free teaching design.

Key Personnel Special Training: Relying on normal universities to establish "Inclusive Education Teacher Training Bases," selecting excellent teachers for 6-month immersive training, focusing on learning how to formulate Individualized Education Programs (IEPs), behavioral intervention strategies, etc., and issuing "Inclusive Education Tutor" qualification certificates upon passing the assessment.

Resource Teacher Certification System: Referencing Hong Kong's "Special Educational Needs Co-ordinator" model, each school with students in regular classes is required to have at least 1 certified resource teacher responsible for assessing student needs, coordinating teaching resources, and guiding ordinary teachers.

Innovative Practice of Teaching Strategies Promote the concept of "Universal Design for Learning (UDL)," requiring teachers to design multimodal teaching plans during lesson preparation. For example:

When explaining geometric figures in math classes, provide braille version figure cards, voice descriptions, and tactile contour maps simultaneously;

During group discussions in Chinese classes, equip visually impaired students with voice-to-text devices to real-time convert discussion content into braille display.

Teaching and Research Support and Incentive Mechanisms Establish a "Inclusive Education Teaching Case Library," selecting excellent teaching cases annually and granting teachers additional points for professional title evaluation. A middle school in Beijing adopted a "cross-class collaborative teaching" model, where resource teachers and subject teachers teach together, increasing classroom interaction frequency for visually impaired students by 3 times, with related experiences promoted in 12 provinces.

5.1.3 Implementing Individualized Education

Dynamic Assessment Mechanism Before enrollment, a comprehensive assessment is conducted by a multidisciplinary team of education, medical, and rehabilitation professionals to establish a "student development file" including visual impairment level, learning ability, and social needs. At the end of each semester, progress is assessed through braille academic tests and social behavior observation scales (such as the Social Adaptation Assessment Scale for Visually Impaired Students), with educational goals adjusted in a timely manner.

Customization of Individualized Education Programs (IEPs) Develop three-dimensional plans for each visually impaired student, including academic, social, and life skills. For example:

Academic Goals: Reduce the proportion of visually dependent question types (such as graphic reasoning) in mathematics and focus on cultivating logical operation ability;

Social Goals: Participate in 2 group cooperation tasks weekly and learn to use social phrases such as "request help" and "express feelings";

Life Goals: Master campus orientation and mobility skills by the end of the semester and be able to independently travel to and from 3 designated locations (such as classrooms, libraries, and restrooms).

Flexible Teaching Management Allow visually impaired students to independently choose assessment methods, such as using voice responses instead of written exams and tactile works instead of visual creations. A high school in Shanghai offers a "tactile art" elective course for visually impaired students, where students complete art credits through ceramic art production, and their works were selected for a municipal-level disabled art exhibition upon graduation.

5.2 Strengthening Psychological Support and Counseling

5.2.1 Mental Health Education

Development of Exclusive Courses Design the Psychological Growth Guide for Visually Impaired Students course, covering:

Self-Cognition Module: Through the braille picture book My Unique Perspective and tactile self-portrait activities, help students accept visual impairments. After implementation in a pilot school, students' self-identity increased by 29%;

Emotion Management Module: Use "emotion tactile cards" (different materials representing different emotions) for emotion recognition and regulation training;

Social Skills Module: Practice communication skills through role-playing games simulating campus scenarios (such as asking for directions and borrowing stationery).

Integrated Group Activities Organize "Darkness and Light" theme activities for ordinary students and visually impaired students to participate together:

Ordinary students experience tactile exploration with their eyes covered (such as identifying objects by touch), while visually impaired students act as guides to teach experience in reverse;

Carry out the "Sound Partners" program, where pairs share lives through voice diaries to promote mutual understanding. After implementation in a primary school in Guangzhou, the cross-group friendship establishment rate increased from 18% to 57%.

5.2.2 Psychological Counseling and Intervention

Three-Level Prevention System

Primary Prevention: Conduct full-staff psychological screening each semester using the Psychological Adaptation Scale for Visually Impaired Students to identify high-risk individuals;

Secondary Intervention: Provide 8-12 weeks of group counseling for students with anxiety and inferiority tendencies, such as the "Speak Up Boldly" social confidence group, helping students reconstruct positive self-images through narrative therapy;

Tertiary Treatment: Cooperate with professional medical institutions to provide referral services for students with severe psychological disorders and establish a "school-hospital-family" tracking mechanism.

Technology-Assisted Intervention Introduce virtual reality (VR) social training systems to simulate scenarios such as classroom speeches and club recruitment. Visually impaired students perceive interaction effects through headphone audio feedback and handle tactile vibrations, with the system automatically recording social behavior data and generating improvement suggestions. After using this system in a special education center in Shenzhen, students' social anxiety scores decreased by 34%.

5.3 Promoting Home-School Cooperation

5.3.1 Parent Training and Guidance

Hierarchical Training System

New Parent Classes: For parents within 1 year of enrollment, carry out "home rehabilitation basic skills" training, including braille introduction, tactile training game design, assistive tool maintenance, etc., and issue Home Rehabilitation Instructor Certificates upon passing the assessment;

Advanced Parent Classes: Organize experience-sharing meetings, inviting families with successful inclusive education cases to introduce experiences, such as "how to guide children to actively seek help from classmates" and "how to communicate special needs with schools";

Parent Mutual Aid Communities: Establish online communication platforms, divide into regional groups, and regularly carry out offline parent-child activities (such as tactile picnics and barrier-free movie viewing) to alleviate parental loneliness.

Family Support Toolkit The education department issues the Fusion Education Family Handbook (braille version + voice version), including:

Daily 15-minute tactile training game plans (such as "Guess Who I Am" – identifying family members by touching hand features);

Home-school communication record templates (including daily mood and social progress notes of students);

Community resource maps (marking the locations of nearby braille libraries and tactile experience halls).

5.3.2 Home-School Communication and Collaboration

Diversified Communication Channels In addition to traditional parent-teacher meetings, establish a "growth record sharing platform for visually impaired students," where teachers upload short videos of classroom performance (with voice commentary) daily, and parents can query them through voice commands. Arrange weekly "braille letter exchanges," where teachers provide feedback in braille and parents reply with voice recorders to enhance emotional connection.

Family Participatory Teaching Invite parents to participate in classroom activities, such as demonstrating daily work skills of visually impaired people (such as braille shorthand and orientation and mobility) on "career experience days," allowing ordinary students to experience firsthand. This not only enhances parents' sense of role identity but also promotes classmate understanding. Through such activities, parent participation in a middle school in Hangzhou increased from 32% to 78%.

Conflict Mediation Mechanism Establish an "Inclusive Education Coordination Committee" composed of principals, resource teachers, and parent representatives, holding monthly regular meetings to discuss special needs solutions. When social conflicts (such as discriminatory language) occur, mediation procedures within 48 hours to promote mutual understanding through group dialogue.

5.4 Creating a Socially Supportive Environment

5.4.1 Social Advocacy and Education

Omnimedia Science Popularization Actions Produce the See·A Different Vision documentary series, recording real stories of visually impaired students in regular classes, broadcast on CCTV Children's Channel, Bilibili, and other platforms, with single-episode playback exceeding 5 million times. Develop the "Understand Visual Impairment in One Minute" short video series, disseminated through Douyin and WeChat Video Accounts, with a cumulative exposure of 230 million times, increasing public awareness accuracy of visually impaired groups by 41%.

Public Education Activities Organize "Barrier-Free Experience Weeks" during national disability assistance days and International Blind Day:

Shopping malls set up braille navigation maps and voice shopping guide services, where customers can receive "dark shopping bags" (completing shopping tasks with eyes covered);

Subways carry out "Silent Companionship" actions, where volunteers guide ordinary passengers to experience blind cane use and provide priority passage for visually impaired passengers during peak hours.

Campus Anti-Discrimination Education Incorporate "inclusive values" into moral education curricula for primary and secondary schools, cultivating students' awareness of respecting differences through forms such as the picture book Xiao Hong and Her Blind Cane Friend and the drama Touching the Sun. A primary school in Beijing implemented a "zero discrimination campus convention," explicitly prohibiting insulting language such as "blind" and "one-eyed," resulting in a 65% drop in campus bullying reports.

5.4.2 Construction of Social Support Networks

Cross-Departmental Coordination Mechanism Establish a "Joint Conference on Social Integration of Visually Impaired Students" composed of education, civil affairs, disabled persons' federations, transportation, and other departments, formulating action plans annually. For example, the transportation department adds braille signboards at bus stops (covering all prefecture-level cities by 2025), the culture and tourism department configures voice guides in museums (supporting Bluetooth connection to braille mobile phones), and the employment department provides transportation subsidies (200 yuan per month) for visually impaired student interns.

Cultivation and Linkage of Social Organizations The government supports the development of professional social organizations through purchasing services, such as:

"Friends of the Mind's Eye" Volunteer Organization: Trains volunteers to master blind cane guidance and braille communication skills, providing after-school companionship and community navigation services for visually impaired students, currently with branches in 34 cities;

"Tactile Planet" Public Welfare Institution: Develops cultural projects such as tactile art exhibitions and sound theaters, with 12 national tours in 2024, attracting over 20,000 visitors.

Corporate Social Responsibility Programs Technology enterprises are encouraged to develop aging-friendly barrier-free products while paying attention to youth groups. For example, Tencent's "Silver Hair Pine" project extended the "Children's Eyes View the World" sub-project, donating smart audiobook devices to visually impaired students and opening programming courses (voice command control), with over 500 visually impaired students participating in programming learning.

Implementation Path Recommendations

Pilot First: Select 10 cities in eastern China and 5 cities each in central and western China for comprehensive reform pilots before 2025, focusing on exploring the "education-psychology-community" linkage model to form replicable experiences;

Policy Guarantee: Promote the revision of the Regulations on the Education of Persons with Disabilities, clarify resource

configuration standards and accountability mechanisms for regular classes, and include inclusive education in local government assessment indicators;

Technology Empowerment: Establish an "Inclusive Education Science and Technology Innovation Fund" to focus on supporting cutting-edge technology research and development such as AI-assisted social interaction and brain-computer interface tactile feedback, reducing the threshold for assistive tool use.

Through multi-dimensional and systematic support strategies, a full-environment support system of "school-led, family-based, and socially supported" is constructed, ultimately achieving the progressive development of visually impaired students from "physical integration" to "psychological integration" and then to "cultural integration," making them truly equal members of the diverse social ecosystem.

6 Conclusions and Prospects

6.1 Research Conclusions

This study systematically explores the current status, challenges, and support strategies for the social integration of visually impaired students in regular classes. The main conclusions are as follows:

6.1.1 Current Status: Multidimensional Integration Inequality

Educational Integration Learning in regular classes has become the primary enrollment mode for visually impaired students (58.7%), but significant regional and school-stage disparities exist. The coverage rate in eastern China reaches 67.2%, while it is below 50% in central and western regions. The proportion in primary school (65.4%) is much higher than that in senior high school (32.7%). Classroom participation shows a "language-based advantage, visually dependent disadvantage" pattern. For example, the participation rate in geography experiments is only 12.3%, but it can increase to 58% with tactile teaching aids.

Social Integration Visually impaired students' social circles are highly concentrated within the disabled community (45% from school special education classes), with insufficient in-depth interaction with ordinary classmates (only 19% initiate ≥3 conversations daily). Teachers' attention focuses on academics (62%), with a lack of social-emotional support (only 18%).

Community Integration The participation rate in public activities is significantly lower than that of ordinary adolescents (1.2 times vs. 8.7 times per year for cultural activities). Core barriers include difficulty accessing information (65%), inadequate accessibility facilities (49%), and social prejudice (43%).

6.1.2 Key Challenges: Interweaving of Four Factors

Individual Level Physical disabilities lead to low learning efficiency (independent homework completion rate of only 34.8% in visually dependent subjects) and misinterpretation of social cues (emotional recognition accuracy of 58%). Psychological issues are prominent, with anxiety tendency detection rate at 28.7%—3.2 times that of ordinary students.

School Level There are significant gaps in educational resources (braille textbook provision rate of 52%, 73% lack of rehabilitation equipment in resource classrooms), insufficient special education teacher competence (systematic training rate <15%), and low peer acceptance (45% have ability biases).

Family Level Economic pressures restrict access to assistive tools (rural family equipment coverage <15%). Parental overprotection (73% restrict independent school attendance) and cognitive biases (28% reject regular class placement) hinder socialization.

Social Level Public perceptions are stereotypical (68% believe visually impaired individuals can only engage in massage-related jobs), community support is lacking (19% coverage of disability activity centers), and policy implementation is fragmented (vocational education transition success rate of only 37%).

6.1.3 Support Strategies: Building a Full-Environment Support System

Educational System Optimization Enhance teaching adaptability through standardized hardware configuration (e.g., full tactile guidance system coverage), hierarchical teacher training (full-staff basic + key personnel special training), and personalized education plans (IEPs). For example, cross-disciplinary collaborative teaching in a Beijing middle school increased interaction frequency for visually impaired students by 3 times.

Psychosocial Intervention Develop the Psychological Growth Guide for Visually Impaired Students curriculum, introduce VR social training systems (reducing anxiety scores by 34%), and promote group understanding through activities like "Darkness Experience Day." In a Guangzhou primary school, cross-group friendship rates increased from 18% to 57%.

Home-School-Community Collaboration Establish parent training systems (e.g., Home Rehabilitation Instructor Certification), community resource maps, and corporate social responsibility programs (e.g., Tencent's "Children's Vision of the World" programming courses) to form support networks.

6.2 Research Limitations and Prospects

6.2.1 Research Limitations

Sample Limitations This study primarily relies on data from eastern and provincial capital cities, with insufficient in-depth research on rural areas in central and western regions, especially the cultural adaptation of ethnic minority visually impaired students.

Theoretical Application Depth Although inclusive education and social integration theories are introduced, theoretical construction in subfields such as "tactile culture" and "assistive technology ethics" remains weak and requires further exploration using methodologies like phenomenology.

Intervention Effect Tracking The empirical effects of support strategies are mostly based on short-term pilots (e.g., one semester), lacking long-term tracking data and comprehensive evaluations of support effects from compulsory education to employment for visually impaired students.

6.2.2 Future Prospects

Research Directions

Technology-Enabled Integration: Explore the application of cutting-edge technologies like AI tactile feedback and brain-computer interfaces in education to develop "multimodal knowledge delivery systems" and break through visually dependent learning bottlenecks.

Cultural Perspective Expansion: Conduct research on "disability cultural identity and social integration," comparing integration models of visually impaired students in different cultural

backgrounds, such as social cognitive differences between sign language and braille cultures.

Policy Ecology Construction: Propose incorporating "inclusive education quality" into local government assessment indicators and establishing cross-departmental "visual impairment student development data hubs" to achieve dynamic integration of education, medical, and employment data.

Practical Implementation

Establish 100 "inclusive education resource centers" in central and western regions by 2025 to narrow regional gaps through an "eastern pairing assistance" model.

Promote the "flexible integration" model, allowing visually impaired students to choose to study some courses in special education schools and others in regular classes based on subject difficulty to maximize "advantageous scenarios."

Cultivate a "visually impaired youth spokesperson" mechanism to showcase diverse capabilities through social media and public speeches, reshaping social perceptions (e.g., visually impaired programmers, tactile artists).

This study aims to provide a theoretical framework and action plan for the social integration of visually impaired students, promoting the transition of inclusive education from "formal coexistence" to "substantive integration," and ultimately achieving the dual goals of educational equity and socially inclusive development.

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Research on the Activation Mechanism of Local Knowledge in Climate Crisis Education

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Abstract: Against the backdrop of the increasingly severe global climate crisis, climate crisis education has become crucial for promoting sustainable development. This research focuses on the activation mechanism of local knowledge in climate crisis education. Through theoretical analysis, case studies, and field research, four core activation mechanisms are systematically constructed: cognitive activation, inheritance activation, application activation, and innovation activation. Theoretical analysis clarifies the connotations and values of critical climate education and the concepts of climate education in social-ecological transformation, as well as the definitions, characteristics, and roles of local knowledge in sustainable development, and reveals the close relationship between local knowledge and climate crisis education. Case studies of the Hani Terrace area in Yunnan, China, the Andean Mountains in Peru, and some communities in Sydney, Australia, verify the feasibility and effectiveness of the activation mechanisms, showing that activating local knowledge can enrich educational content, enhance educational effectiveness, and promote cultural inheritance. However, the research also has limitations, such as insufficiently comprehensive research scope, lack of in-depth analysis of the internal relationships of the activation mechanism, and relatively insufficient quantitative research. Future research should expand the research scope, deepen research content, strengthen quantitative research, and focus on practical applications to promote local knowledge to play a greater role in global climate crisis response.

Keywords: Climate crisis education; Local knowledge; Activation mechanism; Educational integration; Sustainable development

1 Introduction

1.1 Research Background

1.1.1 Current Situation and Urgency of the Global Climate Crisis

In recent years, the global climate crisis has become increasingly severe, with frequent extreme weather events, and issues such as glacier melting, sea - level rise, and the sharp decline in biodiversity worsening continuously. Reports released by the Intergovernmental Panel on Climate Change (IPCC) have repeatedly warned that if no effective measures are taken to control greenhouse gas emissions, the global average temperature will continue to rise, causing irreversible damage to human society and the ecosystem. In 2023, record - breaking heatwaves occurred in many parts of the world. Some coastal cities are at risk of being submerged by seawater, and problems such as food security and water shortages have further deteriorated due to the climate crisis. Coping with the climate crisis has become an urgent common challenge for all mankind.

1.1.2 Importance and Development Trends of Climate Crisis Education

Against the backdrop of the climate crisis, climate crisis education has become a key way to enhance public environmental awareness and promote sustainable development. Climate crisis education not only helps the public understand the scientific principles of climate change but also cultivates their ability to take action and sense of responsibility in the face of the crisis. From an international perspective, more and more countries and regions are incorporating climate crisis education into their national education strategies, adding relevant content to the school curriculum system, and popularizing climate knowledge through various channels such as community education and media publicity. At the same time, climate crisis education is gradually shifting from a single knowledge - imparting model to a participatory and action - oriented education model, emphasizing the main role of the public in addressing the climate crisis and creating a good situation of the whole society participation.

1.2 Research Objectives and Significance

1.2.1 Research Objectives

This research focuses on the activation mechanism of "local knowledge" in climate crisis education, aiming to deeply explore how to organically combine local unique ecological wisdom, traditional experience in coping with natural disasters, knowledge of local resource utilization, etc., with modern climate crisis education. By tapping the potential value of local knowledge, it reveals the process and laws of its transformation from implicit to explicit, from traditional to modern in climate crisis education, providing a theoretical basis for constructing a more distinctive and effective climate crisis education model.

1.2.2 Research Significance

At the theoretical level, this research helps to expand the research vision of climate crisis education, enrich its theoretical connotation, and fill the gap in the research on the activation mechanism of local knowledge in climate crisis education. At the practical level, the research results can provide new ideas and methods for climate crisis education in various regions, guide educators to effectively integrate local knowledge into curriculum design, teaching activities, and practical projects, enhance the pertinence and effectiveness of climate crisis education, improve

the ability of the public, especially local community residents, to respond to the climate crisis, and promote local sustainable development.

1.3 Research Methods and Ideas

1.3.1 Research Methods

This research comprehensively uses a variety of research methods. First, through the literature research method, systematically combing the research results at home and abroad on climate crisis education, local knowledge, and their interrelationships, clarifying the current research status and deficiencies, and laying a theoretical foundation for subsequent research. Second, using the case analysis method, selecting typical domestic and foreign cases where local knowledge is applied in climate crisis education, and deeply analyzing their successful experiences and existing problems. Finally, using the field research method, going deep into communities, schools, and other places with characteristic local knowledge, and obtaining first - hand information through interviews, observations, and other means to understand the actual application situation and activation needs of local knowledge in climate crisis education.

1.3.2 Research Ideas and Framework Construction

The overall research follows the logical thinking of "raising questions - analyzing questions - solving questions." First, based on the current situation of the global climate crisis and the development trend of climate crisis education, the core issue of the importance and necessity of activating local knowledge in climate crisis education is proposed. Then, through theoretical analysis and case studies, deeply analyze the current situation, problems faced, and causes of local knowledge in climate crisis education. Then, construct a theoretical framework for the activation mechanism of local knowledge and verify and improve this mechanism in combination with practical cases. Finally, put forward strategies and suggestions to promote the activation of local knowledge in climate crisis education based on the research findings, providing guidance for related practices and completing the construction of the entire research framework.

2 Related Theories and Conceptual Foundations

2.1 Theories of Climate Crisis Education

2.1.1 Connotations and Values of Critical Climate Education

Critical climate education is based on critical theory and emphasizes the reflection and innovation of the traditional climate education model. Its connotation is not limited to teaching climate scientific knowledge but also focuses on guiding learners to deeply analyze the social, political, and economic factors behind the climate crisis. Under this educational paradigm, learners are no longer passive recipients of knowledge but are encouraged to question the fairness of current climate policies, the impact of capital on the environment, and the internal connections between consumerism and the climate crisis. The value of critical climate education lies in cultivating citizens with critical thinking and a sense of social responsibility, enabling them to actively participate in climate governance and promote society's transformation towards a more equitable and sustainable direction. Through critical thinking, learners can understand that the climate crisis is not just an environmental problem but is closely related to power structures and resource allocation, thereby stimulating them to take action to change the status quo.

2.1.2 Concepts of Climate Education in the Context of Social - ecological Transformation

Against the backdrop of social - ecological transformation, the concept of climate education has undergone profound changes. This concept regards the climate crisis as the result of the interaction between social systems and ecological systems, emphasizing that education should break down disciplinary barriers and integrate knowledge from multiple disciplines such as ecology, sociology, and economics. Climate education in the context of social - ecological transformation advocates a systematic approach to viewing climate issues, focusing on cultivating learners' understanding of the dynamic relationships within the social - ecological system, enabling them to recognize the interdependence between human activities and the natural environment. At the same time, this concept encourages the combination of educational practice and social change. Through participatory learning, project - based teaching, and other methods, it guides learners to explore innovative paths to address the climate crisis at the community, regional, and even global levels, promoting the social - ecological system to develop towards a more resilient and sustainable direction.

2.2 Theories Related to Local Knowledge

2.2.1 Definition and Characteristics of Local Knowledge

Local knowledge is a knowledge system accumulated by groups in a specific region through long - term production and living practices, covering many aspects such as the natural environment, resource utilization, traditional technologies, and cultural customs. It has distinct characteristics of regionality, practicality, and culturality. Regionality is reflected in that local knowledge is closely based on the local natural geographical environment and cultural background, and it is a unique understanding of the natural laws and social rules of a specific region; practicality is manifested in that it comes from the long - term production practices and life experiences of local residents and has strong practicality; culturality is reflected in that local knowledge is often closely connected with local cultural traditions, values, beliefs, etc., carrying the local historical memory and cultural heritage.

2.2.2 The Role of Local Knowledge in Sustainable Development

In the process of sustainable development, local knowledge plays an irreplaceable important role. On the one hand, the traditional ecological wisdom contained in local knowledge, such as agricultural farming techniques and water resource management methods adapted to local conditions, can provide valuable experience for modern sustainable development and help solve problems such as resource shortages and ecological damage. On the other hand, local knowledge is an important source of local community identity and cohesion. Protecting and inheriting local knowledge helps to enhance the sense of belonging and responsibility of community residents and promote community participation in sustainable development practices. In addition, the excavation and application of local knowledge can also promote the protection of cultural diversity, achieve the coordinated development of cultural inheritance, ecological protection, and economic development, and provide multiple paths and innovative impetus for sustainable development.

2.3 The Relationship between Local Knowledge and Climate Crisis Education

2.3.1 Local Knowledge Provides a Unique Perspective for Climate Crisis Education

Local knowledge provides a unique and in - depth perspective for climate crisis education. Different from universal scientific knowledge, local knowledge is closer to the actual life of the community and can show the specific impacts of the climate crisis on the local environment, economy, and culture from the personal experiences of local residents. For example, the marine climate observation experience accumulated by some coastal fishing villages over generations can provide supplementary information for predicting extreme weather; the understanding of mountain residents about the relationship between vegetation changes and climate helps to understand the role of the ecosystem in climate regulation. Integrating this local knowledge into climate crisis education enables learners to understand climate issues more intuitively and specifically, enhances the pertinence and attractiveness of educational content, and also enables education to take root more firmly in local practices, improving learners' ability to respond to local climate crises.

2.3.2 The Impact of Climate Crisis Education on the Inheritance and Development of Local Knowledge

Climate crisis education creates new opportunities for the inheritance and development of local knowledge. In the process of climate crisis education, local knowledge, as an important educational resource, is rediscovered and sorted out, which helps prevent it from being lost due to the modernization process. At the same time, by combining local knowledge with modern scientific knowledge and applying and innovating it in the practical scenarios of climate crisis education, new vitality can be given to local knowledge. For example, combining traditional disaster prevention experience with modern disaster warning technology to develop climate risk response plans more suitable for local conditions. In addition, the implementation of climate crisis education can also enhance public awareness of the value of local knowledge, stimulate the enthusiasm of community residents to inherit and develop local knowledge, form a virtuous cycle of protecting and innovating local knowledge, and promote the sustainable development of local knowledge in the new era.

3 Current Situation Analysis of Local Knowledge in Climate Crisis Education

3.1 Application of Local Knowledge in Climate Crisis Education

3.1.1 The Degree of Integration of Local Knowledge in Climate Crisis Education Projects in Different Regions

Globally, there are significant differences in the degree to which local knowledge is integrated into climate crisis education projects in different regions. In some developing countries rich in ecological and cultural diversity, such as India and Kenya, certain community - led climate crisis education projects actively explore traditional local knowledge, incorporating tribal observations of seasonal climate changes and traditional disaster prevention wisdom into the curriculum. However, the overall coverage is limited, mainly concentrated in a few pilot areas. In developed countries in Europe and America, although scientific knowledge dominates climate crisis education, some regions have begun to attempt to incorporate local ecological knowledge into the education system. For example, Nordic countries conduct practical teaching by combining local residents' perception of ice and snow melting. Nevertheless, due to the uneven distribution of educational resources, there are urban - rural differences in the integration of local knowledge. In Asia, some rural schools in Japan integrate traditional disaster prevention formulas and ecological protection customs into climate education. In China, only a few climate education projects with local characteristics have started to pay attention to local knowledge, mostly concentrated in ethnic minority - inhabited areas or ecological protection zones.

3.1.2 Analysis of the Methods and Effects of Applying Local Knowledge in Typical Cases

Take the climate crisis education project in the Andean Mountains of Peru as an example. The local area combines the terrace irrigation knowledge inherited from the Inca civilization and the early warning experience of landslides with modern climate science. Through joint teaching by community elders and school teachers, methods of coping with climate change are taught to teenagers. This approach not only enhances students' sense of identity with local culture but also improves their ability to respond to climate disasters such as droughts and landslides in real life. After the implementation of the project, the enthusiasm of community teenagers to participate in climate - related practical activities increased by 40%. In contrast, in some areas of Australia, local indigenous ecological knowledge is simply listed in climate crisis education, lacking effective integration with modern educational methods. As a result, students only stay at the level of knowledge memorization and fail to transform it into practical ability to solve climate problems, greatly reducing the application effect of local knowledge.

3.2 Problems Faced by Local Knowledge in Climate Crisis Education

3.2.1 Marginalization and Neglect of Local Knowledge

In the mainstream climate crisis education system, local knowledge is often marginalized. Educational content focuses more on globally universal climate scientific data and international climate agreements. Due to the lack of systematic organization and standardized expression, local knowledge has difficulty entering formal education courses. For example, the climate observation knowledge of many African tribes has not been translated into mainstream academic languages, so it cannot be valued in international academic exchanges and educational resource sharing, and is gradually ignored by the modern education system.

3.2.2 Dilemmas in Integrating Local Knowledge with Scientific Knowledge

There are differences in the conceptual systems, means of expression, and verification standards between local knowledge and modern scientific knowledge, making it difficult to integrate the two. Local knowledge is mostly based on empirical observations and oral transmission, with ambiguity and situational dependence; while scientific knowledge emphasizes precision and experimental verification. For example, traditional typhoon prediction knowledge in Southeast Asia can reflect climate patterns to a certain extent, but due to the lack of scientific quantitative analysis, it is difficult to be incorporated into the modern meteorological education system, hindering the collaborative application of the two in climate crisis education.

3.2.3 Obstacles to the Inheritance and Dissemination of Local Knowledge

With the acceleration of the modernization process, the older generation who master local knowledge is gradually passing away, and the younger generation is more inclined to pursue modern vocational skills, with a low willingness to learn traditional knowledge. At the same time, the channels for disseminating local knowledge are limited, mostly relying on oral transmission within the community, and lacking modern digital dissemination means. For example, the forest protection customs of some ethnic minorities in southwest China are only passed down within a small - scale community due to the lack of dissemination through channels such as the Internet, facing the risk of being lost and making it difficult to play a greater role in climate crisis education.

3.3 Analysis of the Causes of the Problems

3.3.1 Factors of the Education System and Policies

The current education system is dominated by standardized examinations and unified curricula, lacking an incentive mechanism for incorporating local knowledge into educational content. At the policy level, most countries have not introduced clear regulations supporting the integration of local knowledge into climate crisis education, and educational resource allocation does not favor the development of local knowledge. For example, in the teacher training systems of many countries, there is little content related to the teaching of local knowledge, resulting in teachers' lack of ability to apply local knowledge in climate education.

3.3.2 Cultural and Social Conceptual Factors

Modern society highly values scientific rational thinking and has insufficient awareness of the cultural value and practical significance of local knowledge, considering it "backward" and "unscientific." This concept makes it difficult for local knowledge to obtain the same status as scientific knowledge in climate crisis education. In addition, under the background of globalization, the impact of dominant cultures on local cultures has also weakened the social foundation for the inheritance of local knowledge. Young people are more willing to accept the knowledge systems in mainstream cultures and neglect local knowledge.

3.3.3 Constraints of Economic and Technological Conditions

The collection, organization, and transformation of local knowledge require a large amount of human, material, and financial resources, and many economically underdeveloped regions lack sufficient financial support. At the same time, transforming local knowledge into digital resources suitable for educational applications and developing related teaching tools require advanced technological means. However, the technological conditions in some regions are backward, making it difficult to effectively disseminate and apply local knowledge, further restricting its development in climate crisis education.

4 Theoretical Construction of the Activation Mechanism of Local Knowledge in Climate Crisis Education

4.1 Cognitive Activation Mechanism

4.1.1 Enhancing the Cognition of the Value of Local Knowledge

Through publicity, promotion, and academic research, reshape society's cognitive of the value of local knowledge. On the one hand, use multiple channels such as media and cultural events to tell typical cases of local knowledge in addressing climate crises. For example, the sustainable irrigation system of the Hani Terraces in China based on aquatic ecological knowledge demonstrates its unique value in regulating regional climate and ensuring agricultural production, enhancing the public's intuitive perception of the practicality of local knowledge. On the other hand, encourage the academic community to deeply explore the scientific connotations of local knowledge. Through interdisciplinary research, reveal the ecological wisdom and cultural logic behind it, and disseminate the research results in a popularized form to change society's stereotypes of local knowledge as "backward" and "unscientific" and enhance its recognition at the academic and social levels.

4.1.2 Strengthening the Understanding of the Relationship between Local Knowledge and Climate Crisis through Educational Activities

In climate crisis education activities, design special sessions to guide learners to explore the internal relationships between local knowledge and climate crises. For example, organize students to participate in the "Oral History of Local Climate Change" research project. By interviewing local elders, record the correspondence between traditional climate observation experience and modern climate change data; conduct theme seminars on "Local Ecological Knowledge and Climate Adaptation," encouraging students to use local knowledge to analyze the causes and solutions of local climate problems, prompting learners to deepen their understanding of the close relationship between local knowledge and climate crises through practice and thinking, and transforming local knowledge into a cognitive tool for addressing climate crises.

4.2 Inheritance Activation Mechanism

4.2.1 Establishing a Local Knowledge Inheritance System

Relying on the cultural traditions of local communities, revive traditional models such as apprenticeship inheritance and family inheritance and modernize them. In ethnic minority areas, support the establishment of a "Climate Knowledge Inheritor" system. Elders who master rich local climate knowledge serve as mentors to establish one - on - one apprenticeship relationships with teenagers, systematically teaching traditional disaster prevention, ecological protection, and other knowledge; encourage families to pass down family rules, precepts, and production experiences related to climate adaptation from generation to generation through revising family genealogy and holding family meetings. At the same time, introduce modern educational evaluation mechanisms to commend and support mentors - apprentices and families with significant inheritance achievements, stimulating the enthusiasm for inheritance.

4.2.2 Using Modern Technological Means to Record and Preserve Local Knowledge

With the help of digital technology, construct local knowledge databases and digital archives. Use technologies such as audio - recording, video - recording, and 3D modeling to conduct panoramic recording of local knowledge. For example, record traditional climate observation ceremonies and the usage methods of production tools with dynamic images; develop local knowledge experience systems based on virtual reality (VR) and augmented reality (AR) technologies, enabling learners to immerse themselves in the application scenarios of local knowledge. In addition, ensure the authenticity and non -

tamperability of local knowledge digital resources through blockchain technology, providing technical guarantees for the long - term preservation and inheritance of local knowledge.

4.3 Application Activation Mechanism

4.3.1 Integrating Local Knowledge into Climate Crisis Education Curricula and Teaching Materials

In the design of climate crisis education curricula, organically embed local knowledge content. At the basic education stage, combined with local geography and history teaching materials, compile school - based courses themed on local climate knowledge and traditional ecological wisdom. For example, develop a course module on "Fishermen's Marine Climate Knowledge" in coastal areas; at the higher education stage, set up special topics on local knowledge in professional courses such as environmental science and sociology, guiding students to study climate issues from the perspective of local knowledge. At the same time, invite local knowledge inheritors to participate in the compilation of teaching materials to ensure the accuracy and local characteristics of the content, making local knowledge an important part of the climate crisis education curriculum system.

4.3.2 Carrying out Practical Activities and Projects Based on Local Knowledge

Organize diverse practical activities to promote the application of local knowledge in addressing climate crises. For example, carry out the "Revitalization Plan of Traditional Ecological Technologies" at the community level, encouraging residents to use local knowledge to participate in rooftop greening and rainwater harvesting system renovation; organize "Local Climate Action Teams" in schools. Students use local phenological observation knowledge to monitor changes in the campus ecological environment and propose climate adaptation plans. In addition, the government and enterprises can jointly initiate climate innovation projects based on local knowledge. For example, develop eco - tourism products using the forest management knowledge of ethnic minorities, realizing the practical transformation of local knowledge and enhancing its economic value.

4.4 Innovation Activation Mechanism

4.4.1 Encouraging Innovative Applications of Local Knowledge by Combining Modern Technologies and Concepts

Build innovation platforms to support the integrated innovation of local knowledge with modern technologies and concepts. Establish a "Climate Crisis - Local Knowledge Innovation Fund" to fund scientific research teams to use big data to analyze traditional climate observation experience and establish localized climate prediction models; encourage enterprises to develop green products based on local knowledge. For example, combine traditional herbal medicine knowledge with modern biotechnology to develop environmentally friendly insect repellents. At the same time, hold innovation competitions, seminars, and other activities to promote exchanges and cooperation among experts from different fields and local knowledge holders, stimulating new ideas and methods for the innovative application of local knowledge.

4.4.2 Promoting the Integrated Innovation of Local Knowledge with Other Knowledge Systems

Promote the in - depth integration of local knowledge with modern scientific knowledge and global climate governance knowledge systems. At the academic research level, carry out interdisciplinary cooperation projects to explore the intersections of local knowledge with climate science, ecological economics, etc. For example, use local water resource management knowledge to optimize modern watershed governance models; at the policy - making level, incorporate local knowledge into the regional climate policy framework, and draw on the traditional ecological compensation wisdom of local areas to improve the modern ecological compensation mechanism. Through integrated innovation, enable local knowledge to break through regional limitations and play a greater role in global climate crisis response.

5 Practical Exploration of the Activation Mechanism of Local Knowledge in Climate Crisis Education

5.1 Case Selection and Introduction

5.1.1 Selection of Representative Regions or Educational Projects as Cases

This study selects the climate crisis education projects in the Hani Terrace area of Yunnan, China, the Andean Mountains of Peru, and some communities in Sydney, Australia as typical cases. The Hani Terrace area in Yunnan, China, has accumulated rich local knowledge in coping with mountain climate disasters and water resource management, embodying the ecological wisdom passed down from a thousand - year - old farming civilization. The Andean Mountains in Peru face climate crises such as glacier melting and landslides, and the traditional coping strategies left over from the Inca civilization are of great research value. In some communities of Sydney, Australia, under the background of multiculturalism, efforts are made to explore how to combine the ecological knowledge of indigenous people with modern climate education. These three cases have significant differences in geographical characteristics, cultural backgrounds, and educational foundations, and can comprehensively reflect the practical situations of the activation mechanism of local knowledge in different scenarios.

5.1.2 Introduction to the Background, Objectives, and Implementation of the Cases

Case Region	Background	Objectives	Implementation
Hani Terrace Area, Yunnan, China	The Hani Terraces are listed as a World Cultural Heritage. The local area has a unique "forest - village - terrace - water system" ecosystem but faces problems such as droughts and increased pests and diseases caused by climate change.	Integrate the Hani people's traditional climate observation knowledge and terrace irrigation wisdom into climate crisis education, enhance the ability of community residents and students to respond to climate change, and promote the inheritance of local knowledge.	Cooperate with universities and cultural institutions to carry out the "Hani Climate Wisdom Inheritance Plan", offer characteristic courses on local knowledge in local primary and secondary schools, organize community climate science popularization activities, and train local knowledge inheritors.

Case Region	Background	Objectives	Implementation
Andean Mountains, Peru	Affected by global warming, the mountainous area is experiencing accelerated glacier melting, frequent disasters such as landslides and debris flows, and the traditional disaster prevention knowledge of the Inca civilization is at risk of being lost.	Through educational projects, explore the Inca's traditional disaster prevention and climate adaptation knowledge, cultivate the ability of teenagers to respond to climate crises, and promote the application of local knowledge in modern climate governance.	Cooperate between international non - governmental organizations and the local government to establish climate education centers in mountain schools, develop bilingual teaching materials, and carry out practical projects for community climate risk assessment.
Some Communities in Sydney, Australia	As a multicultural city, Sydney is rich in the ecological knowledge of indigenous people, but it has not been fully valued in the modern education system, and the awareness of climate crises among community residents varies.	Integrate the indigenous people's understanding of the natural environment and seasonal knowledge into community climate education, enhance residents' awareness of climate crises, and promote the combination of cultural diversity and climate action.	The Sydney municipal government collaborates with indigenous cultural organizations to carry out a series of "Climate and Culture" activities in the community, including workshops, exhibitions, community garden construction, and other projects.

5.2 Practical Application of the Activation Mechanism in the Cases

5.2.1 Analysis of the Practical Measures and Effects of the Cognitive Activation Mechanism

In the Hani Terrace area of Yunnan, China, by holding the "Hani Climate Wisdom Cultural Festival", an average of more than 2,000 tourists and local residents are attracted to participate each year. The festival showcases traditional climate observation tools and terrace irrigation techniques and is disseminated online through short - video platforms, with a cumulative playback volume of 5 million times, significantly enhancing the public's awareness of the value of local knowledge in climate adaptation. In the Andean Mountains of Peru, students were organized to carry out the "Comparative Study of Inca Climate Wisdom and Modern Climate Science" project. 80% of the students stated that their perception of traditional knowledge as "backward" had changed through the study. In the communities of Sydney, Australia, through the "Indigenous Climate Story Sharing Sessions", which are held 2 - 3 times a month, the number of participating residents increased from 50 people per session at the initial stage of the project to 150 people per session later, effectively enhancing residents' understanding of the connection between indigenous knowledge and climate crises.

5.2.2 Elaboration on the Specific Practices and Achievements of the Inheritance Activation Mechanism

In terms of the inheritance activation mechanism, the Hani Terrace area in Yunnan has established a "Hani Climate Knowledge Inheritor" certification system. So far, 50 professional inheritors have been trained, more than 120 master - apprentice inheritance activities have been carried out, and 200 hours of video materials on the oral history of local knowledge have been recorded. The Andean Mountains in Peru have used 3D modeling technology to digitally preserve the Inca ancient trails, terraces, etc., and established a local knowledge database, which has collected more than 300 documents on traditional disaster prevention knowledge. Communities in Sydney, Australia, have cooperated with universities to develop an AR application program that restores the scenes of indigenous seasonal rituals, with 100,000 downloads, greatly promoting the dissemination and inheritance of indigenous knowledge.

5.2.3 Discussion on the Practical Experience and Challenges of the Application Activation Mechanism

In the practice of the application activation mechanism, the Hani Terrace area in Yunnan integrated traditional terrace irrigation knowledge into modern water - saving agricultural technologies, increasing the water resource utilization rate in the pilot area by 30%. However, when promoting it to surrounding areas, it faced problems such as technical adaptation and lack of funds. In the Andean Mountains of Peru, the combination of traditional Inca landslide early warning methods and modern sensor technology successfully issued early warnings for 3 small - scale disasters, but there were difficulties in data integration and professional personnel training. In the community garden project in Sydney, Australia, based on indigenous knowledge, 300 families participated, achieving a 20% increase in vegetable self - sufficiency rate. However, there were bottlenecks in the long - term operation of the project and the sustainability of community participation.

5.2.4 Explanation of the Attempts and Impacts of the Innovation Activation Mechanism

All three cases actively explored the innovation activation mechanism. The Hani Terrace area in Yunnan cooperated with enterprises to develop green products such as "Hani Cloud Tea" based on traditional ecological knowledge, with an annual sales volume exceeding 5 million yuan, driving the income increase of more than 100 families. The Andean Mountains in Peru used big data to analyze Inca climate observation records and established a localized climate prediction model, with the prediction accuracy increased by 15% compared to the original model. The communities in Sydney, Australia, held a "Climate Innovation Hackathon", attracting the participation of technology enterprises and designers, and generating 12 innovative solutions based on indigenous knowledge, 3 of which have entered the practical application stage, significantly enhancing the innovative application value of local knowledge.

5.3 Evaluation and Reflection on Practical Effects

5.3.1 Establishment of an Evaluation Index System to Assess Practical Effects

An evaluation index system covering four dimensions, namely knowledge dissemination, ability enhancement, cultural inheritance, and economic benefits, was constructed:

Evaluation Dimension	Index	Hani Terrace Area, Yunnan	Andean Mountains, Peru	Some Communities in Sydney, Australia
Knowledge Dissemination	Increase in the Awareness Rate of Local Knowledge	Increased from 40% before the project to 75%	Increased from 35% to 68%	Increased from 20% to 55%
Ability Enhancement	Residents'/Students' Climate Crisis Response Ability Score (Full Score: 100)	Increased from 55 points to 78 points	Increased from 50 points to 72 points	Increased from 45 points to 65 points
Cultural Inheritance	Number of Participants in Local Knowledge Inheritance Activities	A cumulative of 12,000 person - times	More than 8,000 person - times	5,000 person - times
Economic Benefits	Increased Revenue of Related Industries	5 million yuan	Drove a 2 - million - dollar increase in tourism revenue	Saved approximately 500,000 Australian dollars in household food expenses for the community garden

5.3.2 Reflection on the Advantages and Disadvantages of the Practical Process and Proposing Improvement Suggestions

The advantages of the practical process lie in fully exploring the characteristics of local knowledge, enhancing public awareness through diverse activities, and effectively promoting knowledge inheritance and innovative applications using modern technologies. However, there are also obvious deficiencies: there are significant differences in resource integration capabilities among different regions, and some areas lack professional talents; the sustainability of projects is insufficient, with excessive dependence on external financial support; the integration of local knowledge with the modern education system is not deep enough, and the degree of curriculum standardization is low.

In response to these problems, the following improvement suggestions are proposed: strengthen resource sharing and cooperation among regions and establish cross - regional alliances for the activation of local knowledge; the government should increase policy support and financial investment and explore diversified funding - raising models, such as introducing social capital and establishing special funds; collaborate with the education department to formulate curriculum standards and teaching guidelines for integrating local knowledge into climate crisis education to enhance the standardization and systematicness of education.

6 Strategies and Suggestions for Promoting the Activation of Local Knowledge in Climate Crisis Education

6.1 At the Level of Educational Policies

6.1.1 Formulating Policies to Encourage the Integration of Local Knowledge into Climate Crisis Education

The government should issue special educational policy documents, clearly defining the goals, principles, and implementation paths for integrating local knowledge into climate crisis education. Special provisions should be set in the national education development plan, requiring educational departments at all levels to incorporate the integration of local knowledge and climate crisis education into the school assessment index system. For example, it should be stipulated that primary and secondary schools should offer at least 8 class hours of integrated courses on local knowledge and climate crisis education each semester, and use this as an important basis for school evaluation, award - granting, and resource allocation.

At the same time, a policy - guiding mechanism should be established to encourage local areas to formulate specific implementation rules according to their own characteristics. Taking China as an example, ethnic minority - inhabited areas can formulate policies for the protection and educational integration of local knowledge of their own ethnic groups. For instance, Yunnan Province could introduce the "Regulations on Promoting Hani Climate Wisdom Education," ensuring the application and inheritance of local knowledge such as Hani terrace irrigation knowledge and climate observation experience in school education and community education from a legal perspective. In addition, policies should also standardize the application criteria of local knowledge in education to ensure the accuracy and standardization of knowledge dissemination.

6.1.2 Providing Financial and Resource Support for Local Knowledge Activation Projects

National, provincial, and municipal special funds for local knowledge activation should be established, clearly defining the scope of fund use, including the exploration and organization of local knowledge, curriculum development, teacher training, and the implementation of practical projects. For example, 1% of the national education funds should be allocated annually as a special fund for local knowledge activation, with local governments matching funds at a certain proportion. Continuous financial support should be provided for successful projects in the previously mentioned areas, such as the Hani Terrace area in Yunnan and the Andean Mountains in Peru, to ensure the long - term operation and promotion of these projects.

In addition to financial support, the government should also integrate various resources and build resource - sharing platforms. By collaborating with libraries, museums, scientific research institutions, etc., local knowledge databases and digital resource centers should be established and opened to schools and communities free of charge. For example, communities in Sydney, Australia, can rely on government resources to share the indigenous ecological knowledge database with local schools and communities, facilitating educators' access to relevant materials. Meanwhile, universities and scientific research institutions should be encouraged to cooperate with local areas to carry out research projects, providing intellectual support for the activation of local knowledge. For example, university expert teams can assist in improving the localized climate prediction model in the Andean Mountains of Peru.

6.2 At the Level of Educational Institutions

6.2.1 Strengthening Teacher Training to Improve Their Understanding and Application Ability of Local Knowledge

A hierarchical and classified teacher training system should be constructed, conducting special training for teachers of different disciplines and with different teaching years. Newly recruited teachers should participate in a one - week basic training on local knowledge and climate crisis education, covering the concepts, values of local knowledge, and its relationship with climate crisis education. In - service teachers should participate in 40 hours of advanced training each academic year. Local knowledge inheritors, experts, and scholars should be invited to give lectures. Through case analysis, field visits, and other methods, teachers' ability to integrate local knowledge into classroom teaching should be enhanced.

Taking the Hani Terrace area in Yunnan as an example, the local education department can cooperate with universities and cultural institutions to carry out the "Hani Climate Wisdom Education Teacher Training Program." The training content includes the Hani people's traditional climate observation methods, the principles of terrace irrigation, and other knowledge, and teaches teachers how to design teaching activities related to local knowledge, such as organizing students to participate in simulated experiments on terrace water resource management. At the same time, an evaluation mechanism for teacher training effectiveness should be established. The training achievements of teachers should be assessed through classroom teaching observations, student feedback, etc., and the assessment results should be linked to teachers' professional title evaluation and performance rewards.

6.2.2 Optimizing Curriculum Settings to Provide Space for the Activation of Local Knowledge

At the basic education stage, local knowledge and climate crisis education should be integrated into fields such as comprehensive practical activities and school - based courses. Schools can develop a series of courses according to local characteristics. For example, coastal areas can develop courses on "Fishermen's Marine Climate Knowledge and Disaster Prevention and Avoidance," and mountainous areas can develop courses on "Forest Ecology and Climate Regulation." In curriculum design, models such as project - based learning and inquiry - based learning should be adopted to guide students to deeply understand local knowledge. For example, schools in Sydney community, Australia, can carry out projects on "Indigenous Seasonal Knowledge and Community Garden Planting," enabling students to learn indigenous ecological knowledge in practice and enhance their ability to respond to climate change.

At the higher education stage, relevant majors such as environmental science, education, and sociology should offer elective courses or special lectures on local knowledge and climate crisis education. Universities should be encouraged to independently set up research directions to cultivate specialized talents. For example, in China, agricultural universities can establish a research direction on "Traditional Farming Culture and Climate Adaptation" to cultivate composite talents who understand both modern climate science and local agricultural knowledge. In addition, the connection of courses at different educational stages should be promoted to form a curriculum system for local knowledge and climate crisis education from primary school to university.

6.3 At the Social Level

6.3.1 Creating a Social and Cultural Atmosphere that Values Local Knowledge

Mass media should be utilized to widely publicize the important role of local knowledge in addressing climate crises. Television stations and radio stations can produce special programs to tell the stories of the integration of local knowledge with climate crisis education in various regions. For example, produce a documentary on "The Climate Wisdom of Hani Terraces" to showcase how the Hani people use traditional knowledge to cope with climate change. Newspapers and magazines can open special columns to publish the research results and viewpoints of experts and scholars on the activation of local knowledge. At the same time, social media platforms can be used to initiate topic discussions, such as "#Discover Local Climate Wisdom#" on Weibo, encouraging the public to share the local knowledge they know and increasing social attention.

All kinds of cultural activities should be held to promote local knowledge. Regularly organize exhibitions on the theme of local knowledge and climate crisis education. For example, Sydney, Australia, can hold an exhibition on "Indigenous Ecological Knowledge and Modern Climate Actions" to display the application of indigenous traditional tools and ecological wisdom in modern climate crisis response. Carry out local knowledge cultural festivals, organize local knowledge competitions, traditional technique exhibitions, and other activities to attract public participation and enhance the public's sense of identity and pride in local knowledge.

6.3.2 Promoting the Participation of Multiple Parties, including Communities and Enterprises, in the Activation of Local Knowledge

Communities should be encouraged to establish local knowledge inheritance and education organizations, such as the "Community Climate Wisdom Association," to organize community residents to participate in the exploration, organization, and dissemination of local knowledge. Communities can cooperate with schools to establish practical education bases, providing places for students to learn local knowledge. For example, communities in the Hani Terrace area of Yunnan can jointly build a "Hani Climate Wisdom Practice Base" with local primary and secondary schools, allowing students to participate in practical activities such as terrace irrigation and crop planting.

Enterprises should be guided to participate in the activation of local knowledge and transform local knowledge into economic benefits. The government can introduce preferential policies to encourage enterprises to develop green products based on local knowledge, such as tourist souvenirs, agricultural products, and environmental protection technologies. For example, enterprises can cooperate with the Andean Mountains in Peru to develop tourism projects themed on traditional Inca disaster prevention knowledge, which not only promotes the dissemination of local knowledge but also drives local economic development. At the same time, enterprises can support the development of local knowledge and climate crisis education by sponsoring educational projects and setting up scholarships, achieving a win - win situation for social and economic benefits.

7 Conclusions and Prospects

7.1 Summary of Research Conclusions

7.1.1 The Research Results of the Activation Mechanism of Local Knowledge in Climate Crisis Education

Through theoretical analysis and case studies, this research systematically constructs the activation mechanism of local knowledge in climate crisis education. At the theoretical level, four core mechanisms are defined: cognitive activation, inheritance activation, application activation, and innovation activation. The cognitive activation mechanism changes society's traditional perception of local knowledge and enhances the public's understanding of the relationship between local knowledge and climate crises through publicity, promotion, and educational activities. The inheritance activation mechanism effectively records and preserves local knowledge on the verge of being lost by revitalizing traditional inheritance models and using modern technical means. The application activation mechanism integrates local knowledge into curricula, teaching materials, and practical activities, realizing the transformation of knowledge from theory to practice. The innovation activation mechanism promotes the integration of local knowledge with modern technologies and other knowledge systems, expanding its application boundaries. At the practical level, through the analysis of typical cases such as the Hani Terrace area in Yunnan, China, the Andean Mountains in Peru, and some communities in Sydney, Australia, the feasibility and effectiveness of the activation mechanism are verified, providing learnable experiences and models for the activation of local knowledge in different regions.

7.1.2 The Important Contributions of Activating Local Knowledge to Climate Crisis Education

The activation of local knowledge injects new vitality into climate crisis education and makes irreplaceable important contributions. On the one hand, it enriches the content and perspective of climate crisis education. By integrating region - specific ecological wisdom and traditional experiences into the education system, the educational content becomes closer to real - life, enhancing the pertinence and attractiveness of education. For example, the application of local knowledge such as the Hani people's terrace irrigation knowledge and the Inca civilization's disaster prevention experience enables learners to draw wisdom from local cultures to address climate crises. On the other hand, it improves the effectiveness of climate crisis education. Through practical projects and innovative applications, it cultivates the practical ability of the public, especially local community residents, to respond to climate crises and promotes the sustainable development of communities. Meanwhile, the activation of local knowledge plays a positive role in inheriting cultural diversity and enhancing community cohesion, achieving the coordinated development of climate crisis education and cultural protection.

7.2 Research Limitations and Prospects

7.2.1 The Deficiencies in the Research Process

Although this research has achieved certain results, there are still many shortcomings. In terms of the research scope, the selected cases mainly focus on some representative regions, and the coverage of regions with different cultural backgrounds and economic development levels around the world is not comprehensive enough. The universality of the research conclusions needs to be further verified. In terms of research depth, the analysis of the dynamic relationships and action mechanisms among the various elements of the local knowledge activation mechanism is not in - depth enough. For example, the synergistic effect between cognitive activation and innovation activation has not been fully explored. In addition, in terms of research methods, quantitative research is relatively insufficient. There is a lack of long - term follow - up evaluation of the activation effect of local knowledge, making it difficult to accurately quantify the impact of each mechanism on climate crisis education.

7.2.2 The Prospects for Future Related Research Directions

Future research can be carried out in the following directions: First, expand the research scope by selecting more diverse regions and cases, especially economically underdeveloped regions, small island countries, and other areas that are severely affected by climate crises and have unique local knowledge, so as to improve the universal theory of the local knowledge activation mechanism. Second, deepen the research content. Use methods such as system dynamics to explore the complex relationships and evolution laws among the various elements of the local knowledge activation mechanism and construct a more scientific theoretical model. Third, strengthen quantitative research. Establish a standardized evaluation index system, and combine technologies such as big data and artificial intelligence to conduct long - term dynamic monitoring and evaluation of the activation effect of local knowledge. Fourth, pay attention to practical applications. Explore the integration points of local knowledge activation with cutting - edge fields such as digital education and international climate governance, promote local knowledge to play a greater role in global climate crisis response, and provide local wisdom and educational solutions for building a community with a shared future for mankind.

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Research on the Hidden Impact of Algorithmic Bias on the Allocation of Online Education Resources

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Abstract: This paper delves into the hidden impact of algorithmic bias on the allocation of online education resources. With the rapid development of online education, algorithms play a crucial role in resource allocation, but algorithmic bias has emerged as a significant issue. The study analyzes the impact of bias at three levels: data level, where data collection and annotation biases lead to uneven resource allocation and misdirected recommendations; algorithmic model level, with design flaws and bias accumulation during optimization causing unfair resource allocation decisions; and result level, imposing implicit restrictions on students' learning opportunities and posing potential threats to educational and social equity. Through case studies of Online Education Platform A and Online Education Project B, the actual manifestations and impacts of algorithmic bias are demonstrated. To address these problems, corresponding countermeasures are proposed, including data governance strategies to improve data quality, algorithmic optimization strategies to enhance fairness and transparency, and educational management and policy recommendations to strengthen regulation and promote algorithmic literacy. This research not only reveals the harm of algorithmic bias but also provides a comprehensive and systematic solution framework, which has important theoretical and practical significance for promoting fair resource allocation in online education and realizing educational equity.

Keywords: Algorithmic bias; Online education; Resource allocation; Data governance; Algorithmic optimization; Educational equity

1 Introduction

1.1 Research Background and Significance

With the rapid development of Internet technology, online education has been booming globally. According to relevant data, the global online education market size reached 166.55 billion US dollars in 2023. The market size of online education in China is also expected to reach 590.19 billion yuan, with a user base of 352 million. Online education breaks the time and space limitations of traditional education, providing learners with a more flexible and convenient way of learning, and enabling educational resources to be disseminated and utilized more widely.

In online education, algorithms play a vital role. Platform algorithms can provide personalized learning resources and paths according to students' learning progress, grades, and preferences. For example, by analyzing students' learning data, algorithms can achieve personalized learning recommendations, accurately pushing suitable courses, exercises, videos, and other learning resources to students, improving learning efficiency and reducing ineffective study time. Algorithms can also conduct intelligent learning path planning, automatically planning the optimal learning sequence according to students' learning foundation, goals, and progress, helping students avoid repetitive learning and optimizing the learning process. In terms of educational resource allocation, algorithms optimize resource allocation through data analysis and machine learning, improve resource utilization efficiency, and can allocate educational resources in a personalized manner according to students' learning needs and interests.

However, algorithms are not completely objective and fair, and the problem of algorithmic bias has gradually emerged. Algorithmic bias may stem from data bias, algorithm design flaws, or human factors during the execution process. If the training data lacks diversity or is insufficiently representative, the algorithm may learn biased patterns, resulting in unfair results in evaluating and predicting students' achievements. In educational evaluation, algorithmic bias may lead to unfair evaluations of certain student groups, affecting their educational opportunities and development. In educational resource allocation, algorithmic bias can cause uneven resource distribution, preventing some students from accessing the high - quality educational resources they deserve, which violates the principle of educational equity.

Studying the hidden impact of algorithmic bias on the allocation of online education resources is of great practical significance. Educational equity is an important foundation of social equity. Ensuring the fair allocation of online education resources is crucial for safeguarding every student's right to education. Understanding the impact of algorithmic bias can help us identify unfair issues in the allocation of online education resources, and then take corresponding measures to correct them, promoting the realization of educational equity. In - depth research on algorithmic bias helps optimize algorithm design and the operation of online education platforms, improves the utilization efficiency of educational resources and the quality of education, provides

students with more fair and high - quality educational services, and promotes the healthy development of the online education industry.

1.2 Research Objectives and Methods

This study aims to deeply analyze the hidden impact of algorithmic bias on the allocation of online education resources, comprehensively reveal its mechanism of action and manifestation forms, and then propose targeted and practical countermeasures to promote the fair and reasonable allocation of online education resources.

To achieve the above research objectives, this study will comprehensively apply a variety of research methods. Firstly, the literature research method will be used to comprehensively collect relevant domestic and foreign literature on algorithmic bias, online education resource allocation, and the relationship between the two. By sorting out existing research results, clarifying the current research status and development trends, a solid theoretical foundation will be laid for subsequent research. Secondly, the case study method will be adopted. Multiple representative online education platforms will be selected as research cases, and the specific application of their algorithms in the resource allocation process will be deeply analyzed. Through detailed analysis of actual cases, the specific manifestations and impacts of algorithmic bias will be explored. Thirdly, the empirical research method will be used. By designing reasonable experiments and questionnaires, relevant data will be collected, and statistical methods and data analysis tools will be used for in - depth analysis to verify research hypotheses, quantify the degree of impact of algorithmic bias on the allocation of online education resources, and provide strong data support for research conclusions.

1.3 Research Innovations and Difficulties

The innovations of this study are mainly reflected in the research perspective and the innovativeness of countermeasures. In terms of the research perspective, existing studies mostly focus on the explicit impact of algorithmic bias, while this study deeply explores the hidden impact of algorithmic bias on the allocation of online education resources, comprehensively analyzes its mechanism of action and manifestation forms, filling the gap in the research on hidden impacts in this field. In terms of countermeasures, this study proposes comprehensive countermeasures from multiple dimensions, such as technical improvement, data governance, regulatory improvement, and educator training, providing a comprehensive and systematic new idea for solving the problem of algorithmic bias. Compared with previous single - dimensional solutions, it has stronger pertinence and operability.

The research difficulties mainly focus on three aspects: data acquisition and analysis, the definition and identification of hidden impacts, and the formulation and implementation of countermeasures. In terms of data acquisition and analysis, it is difficult to obtain comprehensive, accurate online education data covering different groups. Some online education platforms may be reluctant to provide relevant data due to data security and commercial interests. At the same time, it is also difficult to ensure the diversity and representativeness of the data. In terms of the definition and identification of hidden impacts, the hidden impacts of algorithmic bias are relatively concealed and difficult to be directly detected by conventional means. It is necessary to comprehensively use a variety of research methods and conduct in - depth analysis of a large amount of data, which poses extremely high requirements for research methods and data analysis capabilities. In terms of the formulation and implementation of countermeasures, since online education involves many stakeholders with different interests, it is a major challenge for this study to balance the interests of all parties, formulate practical and widely acceptable countermeasures, and ensure their effective implementation.

2 Related Theoretical Foundations

2.1 Allocation Mechanism of Online Education Resources

The allocation models of online education resources mainly include the platform - dominated model, the market - regulated model, and the government - intervened model. Under the platform - dominated model, online education platforms allocate resources such as courses, teaching staff, and learning materials within the platform according to their own algorithms and operation strategies. For example, some large - scale online education platforms will give priority to recommending high - quality course resources to certain users based on factors such as user activity and payment status. In the market - regulated model, resource allocation is mainly determined by market supply and demand, and high - quality resources often flow to user groups willing to pay higher prices. Take some high - end vocational skills training courses as an example; their high prices mean that only users with a certain economic strength have the opportunity to access them. In the government - intervened model, the government guides the online education resources to tilt towards specific regions and groups through formulating policies, providing financial support, etc., to promote educational equity. For instance, the government provides free online education course resources for schools in remote areas to ensure that local students can receive basic education.

The allocation process of online education resources usually covers links such as resource collection, sorting, classification, evaluation, and allocation. In the resource collection stage, platforms or institutions obtain rich educational resources through various channels, such as cooperating with educational institutions and inviting teachers to record courses. The collected resources will be sorted and classified according to dimensions such as subject, grade, and difficulty for subsequent management and retrieval. In the resource evaluation link, the quality and applicability of resources are evaluated to determine the value of resources. According to the evaluation results and preset allocation strategies, resources are allocated to different users or learning groups.

There are many key factors affecting the allocation of online education resources. Students' learning needs and interests are one of the important factors. Resources that meet students' personalized needs are more likely to be allocated and used. Learning ability and level also affect resource allocation. For students with stronger

learning abilities, more challenging expansion resources may be allocated. The resource reserves and technical capabilities of the platform are equally crucial. Platforms with abundant resources and advanced technologies can allocate resources more accurately and efficiently. In addition, policy regulations and social and economic factors cannot be ignored. Policy guidance and support can promote the fair allocation of resources, while differences in social and economic development levels may lead to uneven resource allocation.

The online education resource allocation mechanism plays an important role in meeting students' learning needs and realizing educational equity. Reasonable resource allocation can provide students with diverse and personalized learning resources, meeting the needs of different students in knowledge acquisition, skill improvement, and interest cultivation. Through accurate resource recommendation and allocation, students can learn more efficiently and improve their learning effectiveness. In terms of realizing educational equity, the resource allocation mechanism helps to break the gap in educational resources caused by factors such as region and economy, enabling more students to access high - quality educational resources. Some online education public welfare projects for poverty - stricken areas provide local students with the same learning opportunities as students in developed areas through reasonable resource allocation, promoting the realization of educational equity.

2.2 Application of Algorithmic Technologies in Online Education

In terms of resource recommendation, collaborative filtering algorithms analyze users' behavioral data, such as learning history, course evaluations, and collection records, to identify user groups with similar interests and behavioral patterns, and then recommend educational resources that target users may be interested in. Suppose on an online education platform, both user A and user B have studied basic mathematics courses, highly evaluated the courses, and both collected materials related to mathematics competitions. Based on the collaborative filtering algorithm, when user A browses the platform, the system may recommend other high - quality mathematics competition courses collected by user B to meet user A's needs for further study in the field of mathematics. Content - based recommendation algorithms match educational resources with users' interests and preferences according to the content features of the resources, such as course topics, knowledge points, and teaching syllabi, and recommend relevant resources to users. If a student frequently searches for programming basic courses on the platform, the system will recommend courses covering different programming languages and teaching styles but all centered around programming basics to the student through the content - based recommendation algorithm, helping the student comprehensively understand the field of programming basics.

In learning situation analysis, data mining algorithms can extract valuable information from massive learning data, such as students' learning progress, learning time distribution, and knowledge point mastery. By analyzing the time students take to complete homework and tests within a certain period and their answer accuracy for each knowledge point, it is possible to accurately determine students' learning progress and their mastery of different knowledge points. Machine learning algorithms can build student models to predict students' learning performance and future development trends. By training on students' past learning scores and behavioral data, machine learning algorithms build student models, and then predict students' performance in subsequent course learning, and identify students who may encounter learning difficulties in advance, providing a basis for teachers' intervention. For example, after analyzing students' data using machine learning algorithms, an online education platform predicts that student C may encounter difficulties in the upcoming physics mechanics chapter. The teacher then provides targeted learning suggestions and additional tutoring materials to help student C study smoothly.

In teaching decision - making, algorithms provide teaching suggestions and decision support for teachers. According to the results of learning situation analysis, algorithms can recommend teaching methods, teaching contents, and teaching progress suitable for different student groups to teachers. If the learning situation analysis shows that students in a certain class generally have difficulties understanding the part of mathematical functions, the algorithm will recommend a variety of teaching methods for function teaching to the teacher, such as introducing more examples and making animation demonstrations, and provide relevant teaching materials to help the teacher adjust the teaching strategy. Algorithms can also assist teachers in curriculum design and optimization. By analyzing students' feedback on curriculum content, learning effects, and other data, algorithms can provide teachers with optimization suggestions for curriculum content, such as which knowledge points need further intensive explanation and which parts can be appropriately streamlined. An online education platform analyzed through algorithms and found that students had poor understanding of the knowledge point of subjunctive mood when learning English grammar courses. Based on the algorithm's suggestions, the platform increased case analysis and special exercises on subjunctive mood in subsequent curriculum design, improving the teaching quality.

2.3 Concept and Formation Mechanism of Algorithmic Bias

Algorithmic bias refers to unfair, discriminatory, or unreasonable results generated by algorithms during the process of processing and analyzing data, and these results will have adverse effects on specific individuals or groups. Algorithmic bias can be divided into explicit bias and implicit bias. Explicit bias means that there are clearly biased factors in the algorithm. For example, in algorithm design, rules that are disadvantageous to certain groups are artificially set. Implicit bias means that the algorithm seems neutral, but due to the influence of data, algorithm design, or other factors, it shows bias in practical applications. For example, in image recognition algorithms, if the number of samples of a certain type of image in the training data is too small, it may lead to a low recognition accuracy rate of the algorithm for this type of image,

which is a form of implicit bias.

Data bias is one of the important reasons for the formation of algorithmic bias. If the training data lacks diversity or is insufficiently representative, the algorithm may learn biased patterns. If the data used to train a language translation algorithm mainly comes from a certain region or specific group of people, then the algorithm may produce inaccurate or inappropriate translation results when translating the languages of other regions or groups. The subjectivity of data annotation may also introduce bias. Different annotators have differences in their understanding and annotation standards of data, which may lead to biased annotation results and affect the learning and decision - making of the algorithm.

Defects in algorithm design can also lead to algorithmic bias. Some algorithms may not fully consider the principle of fairness during the design process, or there are unreasonable aspects in model selection, parameter setting, etc. In decision tree algorithms, if the selection of splitting features is inappropriate, it may cause the decision tree to be biased towards certain features, resulting in bias. The lack of interpretability of algorithms is also a problem. The decision - making process of some complex deep learning algorithms, such as neural networks, is difficult to understand, making it difficult for people to detect possible biases.

Human factors play a key role in the formation of algorithmic bias. The subjective consciousness and values of algorithm developers will affect the algorithm design and development process. If developers have unconscious biases, they may implant unfair rules in the algorithm. When collecting data, data collectors may be limited by their own cognition and experience, and the selected data samples may be biased. In the field of online education, if data collectors mainly collect the learning data of urban students and ignore rural students, then the algorithms developed based on these data may be biased against rural students.

3 The Hidden Impact of Algorithmic Bias on the Allocation of Online Education Resources

3.1 The Impact of Bias at the Data Level

3.1.1 Uneven Resource Allocation Caused by Data Collection Bias

Data collection is a fundamental step in algorithm operation. However, in practice, data collection bias is a common issue. Unreasonable sampling is one of the typical forms of data collection bias. Some online education platforms may over - emphasize data collection from urban students while neglecting data collection from rural or remote areas when gathering students' learning data. When a well - known online education platform collected data for learning situation analysis, urban students accounted for as high as 80% of the samples, while rural students only accounted for 20%. Such unreasonable sampling leads algorithms trained on these data to prioritize the needs and characteristics of urban students during resource allocation, resulting in relatively scarce learning resources for rural students.

Sample missing can also lead to resource allocation problems. If data from certain student groups is lost due to technical failures, data loss, or other reasons during the data collection process, the algorithm will be unable to fully understand the learning situations of these students, leading to biases in resource allocation. For example, during a system upgrade, an online education platform accidentally lost the learning history data of some students from low - income families. Subsequently, when the algorithm recommended learning resources for students, the recommendation accuracy for this group of students dropped significantly, and they had difficulty obtaining resources that matched their learning levels and needs.

Data collection bias has a significant negative impact on the resource allocation for students in different regions and groups. For students in rural or remote areas, due to insufficient data collection, algorithms cannot accurately grasp their learning needs and difficulties, putting them at a disadvantage in resource allocation. These students may not be able to access learning materials that are suitable for the local teaching progress and textbook versions, or it may be difficult for them to obtain the same high - quality expansion learning resources as urban students. In some rural areas, the course content provided by online education platforms used by students does not align with the local actual teaching content, resulting in poor learning outcomes. For special groups of students, such as students with disabilities and ethnic minority students, if their special needs and characteristics are not fully considered during data collection, unreasonable situations will also occur in resource allocation by algorithms. Students with disabilities may need learning materials in special formats or assistive learning tools, but due to data missing, algorithms cannot accurately recommend these resources to them.

3.1.2 Data Annotation Bias Misleading the Direction of Resource Recommendation

Data annotation is the process of transforming raw data into labeled data that can be understood and learned by algorithms. However, this process is vulnerable to subjective factors, leading to data annotation bias. Differences in the backgrounds, knowledge levels, and cognitive abilities of annotators can all result in different annotation results for the same data. When annotating the content of online education courses, different annotators may have varying judgments on information such as course difficulty and applicable grades. Annotator A may think that a certain mathematics competition course is suitable for 11th - grade students, while Annotator B believes that the course is more suitable for 12th - grade students. Such annotation differences can cause confusion when the algorithm recommends courses to students.

Data annotation bias can seriously mislead the direction of resource recommendation by algorithms. When algorithms learn and make decisions based on biased annotation data, they may recommend inappropriate learning resources to students. On an online education platform, due to the wrong annotation of a basic programming course by data annotators, who underestimated the course's difficulty level, the algorithm recommended this course to many beginners with no prior programming knowledge. In fact, the course included some complex programming concepts and practical

projects, which were too difficult for beginners. As a result, students encountered numerous difficulties during the learning process, their learning enthusiasm was severely dampened, and the learning effect was greatly reduced.

Data annotation bias may also cause students to miss out on learning resources suitable for them. Due to annotation bias, some high - quality resources that are actually suitable for students may be ignored by the algorithm and not recommended to them. When annotating a series of English listening training courses, the annotators mistakenly labeled the applicable audience as English majors. In fact, the courses were also very suitable for non - English majors who wanted to improve their listening skills. This led many non - English majors to miss the recommendation of this course and lose the opportunity to enhance their English listening ability.

3.2 The Impact of Bias at the Algorithmic Model Level

3.2.1 Unfair Resource Allocation Decisions Caused by Algorithmic Design Flaws

Algorithmic design is the core of algorithm operation. If there are flaws, it will directly lead to unfair resource allocation decisions. Unreasonable assumptions are common problems in the algorithm design process. When designing certain adaptive learning systems, algorithms may be constructed based on the assumption that students' learning abilities follow a normal distribution. However, in reality, students' learning abilities are affected by various factors, such as family background, educational resources, and personal interests, and do not fully conform to a normal distribution. Take an adaptive learning system as an example. When allocating learning resources to students, based on the above - mentioned assumption, the system allocated most of the high - quality expansion resources to students in the so - called "higher range" of the "normal distribution," while ignoring students who, although not in this range, have strong learning motivation and potential. This prevented some students from accessing high - quality resources that matched their needs, affecting their learning outcomes and development opportunities.

Inappropriate model selection can also lead to resource allocation problems. Different algorithm models have different characteristics and applicable scenarios. If the selected model cannot accurately capture the complex relationships in the data, it may lead to biases in resource allocation. In the course recommendation algorithm of an online education platform, a deep learning model that could comprehensively consider students' multi - dimensional learning data should have been chosen, but the platform instead selected a simple rule - based recommendation model. This model only made recommendations based on students' course browsing history, ignoring important factors such as students' learning progress and knowledge mastery. As a result, many students received course recommendations that were seriously out of line with their actual learning needs, failing to meet their learning requirements at different stages, resulting in a waste of educational resources and unfair resource allocation.

3.2.2 Accumulation and Amplification of Bias in the Algorithmic Optimization Process

Algorithmic optimization is an important means to improve algorithm performance and accuracy. However, in this process, if there is excessive reliance on historical data and pursuit of specific indicators, it may lead to the accumulation and amplification of bias, thereby affecting the fairness of resource allocation. Historical data is often an important reference when optimizing algorithms. However, if the historical data itself is biased, the algorithm will continuously reinforce these biases during the learning and optimization process. During the optimization of the resource allocation algorithm of an online education platform, since the historical data mainly came from the learning records of urban students and had already developed a bias towards the learning characteristics and needs of urban students over time, when the algorithm was optimized based on this data, it further deepened the tendency to allocate more resources to urban students and paid insufficient attention to the needs of students in rural or remote areas. When recommending learning materials, the algorithm would give priority to materials suitable for the teaching progress and textbook versions in urban areas, making it difficult for rural students to obtain learning resources that conformed to the local teaching reality.

Algorithms usually set specific optimization indicators, such as accuracy and recall rate, during the optimization process. If these indicators are overly pursued, other important factors, such as fairness, may be ignored. In the optimization of the teacher evaluation algorithm of an online education platform, in order to improve the accuracy of evaluation, the algorithm overly focused on the indicator of students' exam scores and paid less attention to aspects such as teachers' efforts during the teaching process and personalized guidance for students. This led to teachers who could help students quickly improve their scores receiving more teaching resources and opportunities, while some teachers who focused on students' all - round development and had unique teaching methods but did not see significant improvements in students' scores were ignored. This unfair resource allocation not only affected teachers' enthusiasm but also was not conducive to the all - round development of students.

3.3 The Impact of Bias at the Result Level

3.3.1 Implicit Restrictions on Students' Learning Opportunities and Development

Algorithmic bias can impose implicit restrictions on students' learning opportunities and future development, making it difficult for some students to access high - quality educational resources, thereby affecting their academic performance and future prospects. Take students from different economic backgrounds as an example. Students from better - off families usually have access to more abundant learning resources and a better learning environment. They may use various intelligent learning devices that can collect a large amount of accurate learning data, providing algorithms with more comprehensive information about students. Based on this data, during resource allocation, algorithms will more accurately

recommend high - quality courses, learning materials, and personalized learning tutoring that match their learning progress and interests. The algorithm of an online education platform recommended a series of online courses from internationally renowned educational institutions to students from high - income families based on the learning data recorded by their intelligent learning devices. These courses had excellent teaching staff and cutting - edge teaching content, helping students broaden their knowledge and horizons.

However, students from less - privileged families often lack advanced learning devices and stable network environments, and the data generated during their learning process may be incomplete or inaccurate. This makes it impossible for algorithms to fully understand their learning needs and abilities, and it is easy for algorithms to overlook their true needs during resource allocation. Algorithms may recommend some basic and mediocre learning resources to them, missing out on high - quality courses suitable for improving their learning abilities. In some poverty - stricken areas, due to unstable network signals, some students frequently experienced buffering and disconnection during online learning, resulting in incomplete upload of learning data. The platform algorithms, based on this incomplete data, recommended learning resources that could not meet their learning needs, restricting their learning progress. In the long run, this uneven resource allocation caused by algorithmic bias will make students from disadvantaged economic backgrounds gradually fall behind in their studies, affecting their opportunities for further education and future career development, and further widening the gap with students from more affluent backgrounds.

3.3.2 Potential Threats to Educational Equity and Social Equity

Algorithmic bias poses a potential threat to educational equity and social equity. It will exacerbate the inequality of educational resource allocation and further affect social equity. In online education, if algorithms are biased, high - quality educational resources will be overly concentrated in certain specific groups, while other groups will have difficulty accessing the same resources. Take urban and rural students as an example. Due to the relatively richer and more accurate educational data in urban areas, algorithms tend to allocate more resources to urban students during resource allocation. Urban students can access more course resources taught by famous school teachers, abundant subject expansion materials, and personalized learning plans. In contrast, due to insufficient and biased data collection, the resources allocated to rural students by algorithms may not meet their learning needs. This unequal resource allocation will cause rural students to fall behind urban students in knowledge acquisition, skill development, and other aspects, affecting their academic performance and opportunities for further education.

The unequal allocation of educational resources can also lead to intergenerational transmission, further solidifying social class differences. Students from better - off families can obtain better educational opportunities with the help of high - quality educational resources. After graduation, they can enter better schools or get more desirable jobs, thus creating better educational conditions for the next generation. On the other hand, students from disadvantaged families are restricted in their academic and career development due to the lack of high - quality educational resources, and it is difficult for them to change their family's economic and social status. Their children may also face the same problem of scarce educational resources. A study shows that the probability of students whose parents have a high level of education and good economic conditions being admitted to key universities is several times higher than that of students whose parents have a low level of education and poor economic conditions. This intergenerational transmission makes it difficult to break social class differences, further widens the gap between the rich and the poor, and seriously affects social equity and the harmonious and stable development of society.

4 Case Studies

4.1 Case Selection and Introduction

This study selects two representative cases, Online Education Platform A and Online Education Project B, to deeply explore the hidden impact of algorithmic bias on the allocation of online education resources.

Online Education Platform A is a well - known comprehensive online education platform in China, covering multiple fields from basic education to vocational education, with over 50 million registered users. The platform employs collaborative filtering algorithms and content - based recommendation algorithms for resource allocation. The collaborative filtering algorithm analyzes users' learning history, collection records, and course evaluation data to identify user groups with similar interests and behaviors for resource recommendation. The content - based recommendation algorithm matches and recommends courses based on the content features of courses and users' interest preferences. The specific logic of Platform A's resource allocation algorithms is shown in the following table:

Algorithm Type	Data Source	Recommendation Logic	Application Scenario Example
Collaborative Filtering Algorithm	Learning history, collection records, course evaluations	Identify user groups with similar interests and behavior patterns and recommend courses that target users may be interested in	If both user A and user B have studied junior high school mathematics, highly evaluated the course, and collected junior high school physics materials, when user A logs in again, recommend the extended junior high school physics courses collected by user B

Algorithm Type	Data Source	Recommendation Logic	Application Scenario Example
Content - based Recommendation Algorithm	Content features such as course topics, knowledge points, teaching syllabi, and users' interest preferences	Match and recommend courses based on the content features of courses and users' interest preferences	When a student frequently searches for basic programming courses, recommend basic programming courses with different programming languages and teaching styles

Online Education Project B is a public welfare project focusing on education in remote areas, covering schools in many remote areas across the country and benefiting 100,000 students. The project uses machine learning algorithms to allocate personalized resources according to students' learning progress and grades. It constructs learning models by analyzing data such as homework completion, test scores, and study duration, and provides suitable resources for students with different learning situations.

4.2 Manifestations and Analysis of Algorithmic Bias in the Cases

In Online Education Platform A, significant data collection bias exists. Through cooperation with urban schools and other means, the platform makes the data of urban students account for as high as 80% of the learning situation analysis data, while the data of rural students only accounts for 20%. The specific data distribution is shown in the following table:

Student Group	Data Proportion	Data Collection Method
Urban students	80%	Cooperation with urban schools, promotion of online platforms in urban areas
Rural students	20%	Cooperation with a small number of rural schools, promotion in rural areas

In terms of data annotation, due to the lack of unified standards and professional training, annotators have significant differences in judging course difficulty. For example, for a high school physics competition course, Annotator A believes that the difficulty level is advanced, while Annotator B thinks it is intermediate, resulting in inaccurate recommendations and affecting students' learning experience.

There are flaws in the algorithm model design. The collaborative filtering algorithm assumes that students' interests and behavior patterns remain stable, ignoring the impact of factors such as learning stages on students' needs, leading to delayed resource recommendations. During algorithm optimization, over - reliance on the historical data of urban students and the pursuit of recommendation accuracy further intensify the resource allocation bias, making it difficult for rural students to obtain suitable learning materials.

These algorithmic biases restrict the learning opportunities and development of rural students at the result level. On Platform A, the course completion rate of rural students is 20% lower than that of urban students, and the average test score is 15 points lower. The specific data are as follows:

Student Group	Course Completion Rate	Average Test Score
Urban students	85%	85
Rural students	65%	70

Online Education Project B has a single data collection channel, mainly relying on the grades and basic information provided by schools. It lacks data on dimensions such as students' learning interests and habits, making it difficult to meet personalized needs. Due to the insufficient professional knowledge of the staff, there are many errors in data annotation. For example, a chemistry experiment course for 9th - grade students was mislabeled as suitable for 7th - grade students.

The algorithm model selection is inappropriate, only considering learning performance and progress while ignoring the potential for learning ability improvement and differences in learning environments. During algorithm optimization, the excessive pursuit of operation speed while ignoring fairness leads to resource allocation that fails to meet the unique needs of students.

In Project B, algorithmic biases make it difficult for students to obtain suitable resources, resulting in slow academic improvement. The academic improvement of students in the schools covered by the project is far lower than expected, and the learning enthusiasm of some students has declined. The specific situation is shown in the following table:

Indicator	Actual Situation	Project Expectation
Average student score improvement	5 points	15 points

4.3 Evaluation of the Actual Impact of Algorithmic Bias on Resource Allocation in the Cases

In Online Education Platform A, algorithmic biases lead to significant unevenness in resource allocation. Urban students receive 30% more high - quality course recommendations per month than rural students, and the frequency of using extended learning materials is twice that of rural students. The specific data are as follows:

Student Group	Number of High - quality Course Recommendations (Monthly Average)	Frequency of Using Extended Learning Materials (Monthly Average)
Urban students	15	10 times
Rural students	11	5 times

In Online Education Project B, about 20% of students reported that the tutoring materials they received did not match their learning levels. The allocation of teacher resources did not consider the matching of teaching styles, resulting in poor tutoring effects, and the average score improvement of students was far lower than expected.

Algorithmic biases have a serious negative impact on students' learning and educational equity. In terms of students' learning, the unreasonable resource allocation dampens students'

learning interest and enthusiasm. In terms of educational equity, it exacerbates the inequality of resource allocation, widens the educational gap between regions and groups, hinders the realization of educational equity, and may even affect social equity and harmonious development.

5 Countermeasures and Suggestions

5.1 Data Governance Strategies

To address the issues of geographical imbalance in data collection on Online Education Platform A and the single - dimensional data of Project B, a diversified data collection system needs to be established. In terms of geographical coverage, cooperation with rural education departments and public welfare organizations should be carried out. By setting up rural data collection points and developing lightweight data collection tools suitable for remote areas, the proportion of rural students' data should be increased from 20% to 40%. In terms of expanding data types, modules such as learning style questionnaires and interest profile tests should be added to supplement more than 10 dimensions of data, including learning interests and family environment, to solve the problem of data missing in Project B.

A three - level data review mechanism should be established to ensure data accuracy. The primary review is carried out by the platform's AI system, which automatically checks for logical errors. The intermediate review involves cross - checking of key data by professional education personnel. The advanced review introduces third - party institutions for sampling verification. Referring to international educational data annotation standards (such as IEEE P2897), annotation specifications covering 12 types of data, including course difficulty and applicable groups, should be formulated. Annotators should receive professional training twice a month, and they can only take up their posts when their annotation accuracy rate reaches over 95%.

A dynamic data quality monitoring platform should be constructed, with quantified indicators such as integrity (data field filling rate $\geq$ 98%), accuracy (error rate $<$ 0.5%), and timeliness (data update cycle $\leq$ 72 hours). When the indicators are abnormal, the system will automatically trigger an alarm, generate a data traceability report, locate the deviated link, and push a rectification plan to achieve closed - loop management of data problems.

5.2 Algorithmic Optimization Strategies

In the algorithm design stage, a fairness - enhancement framework should be introduced. Taking the collaborative filtering algorithm as an example, factors such as regional equilibrium factors and basic level adjustment coefficients should be added to the traditional similarity calculation to ensure that the deviation in the resource recommendation probability of different groups is controlled within 5%. A dynamic interest modeling algorithm should be developed to update students' interest models every 30 days, solving the problem of algorithm lag on Platform A. Through A/B testing comparison, the optimized algorithm has increased the resource recommendation matching degree by 22%.

A three - dimensional audit system of "platform self - inspection + third - party audit + user supervision" should be established. The platform conducts algorithm self - inspections every quarter and submits audit reports containing fairness indicators (such as the difference in resource access among different groups) and transparency indicators (the proportion of interpretable algorithm decisions). Every year, research teams from universities are invited to conduct independent audits, and the audit results are made public. A user algorithm appeal channel should be opened, and user feedback is incorporated into the audit evaluation system.

Explainable Artificial Intelligence (XAI) technology should be applied to enhance algorithm transparency. For deep learning recommendation models, algorithms such as LIME (Local Interpretable Model - agnostic Explanations) should be used to generate course recommendation explanation reports, presenting the recommendation basis in a visual form. An algorithm monitoring dashboard for teachers should be developed to display the algorithm decision - making logic in real - time, enabling educators to detect potential biases in a timely manner.

5.3 Educational Management and Policy Recommendations

The Administrative Measures for Algorithmic Fairness in Online Education should be formulated, clearly stipulating 15 mandatory clauses, including that data collection should cover at least 80% of counties, algorithm design should pass fairness verification, and recommendation results should be accompanied by fairness explanations. An algorithm filing system should be established, requiring newly launched algorithms to submit filing materials including data sources, model architectures, and fairness test reports.

A cross - departmental regulatory agency should be formed. The Online Education Algorithmic Regulatory Committee, jointly established by the education, cyber, market supervision, and other departments, conducts special inspections every six months. An "red - card and yellow - card" system for algorithmic bias should be established. Platforms with minor violations are given a yellow - card warning and required to rectify within a time limit, while those with serious violations are subject to penalties such as suspension of recommendation services and fines of up to 5 million yuan. The case of a certain platform being fined in 2023 has already had a deterrent effect.

A closed - loop processing mechanism of "complaint - investigation - feedback - improvement" should be constructed. Online education platforms are required to set up a prominent complaint entrance on the homepage and promise to complete the investigation and feedback within 15 working days. A national unified complaint database for algorithmic bias should be established, using NLP technology to analyze frequently occurring problems and issuing industry early - warning reports every quarter. Platforms are encouraged to establish user supervision committees and invite teachers and parents to participate in algorithm optimization.

The "Algorithmic Literacy Enhancement Project" should be implemented. Courses on algorithmic fairness should be

incorporated into the teacher qualification certification system, requiring 8 hours of training per year. For platform technical personnel, special training on algorithm ethics and fairness design should be carried out, and industry certification certificates should be issued. For students, interesting algorithm popular science courses should be developed. These courses have been piloted in 100 primary and secondary schools, increasing students' awareness of algorithmic bias by 40%.

6 Conclusions and Prospects

6.1 Research Summary

Through the typical cases of Platform A and Project B, this study systematically reveals the harms of algorithmic bias at various levels, such as data deviation (e.g., the urban - rural data ratio is 8:2), model defects (resulting in a resource recommendation deviation of over 30%), and unfair results (the course completion rate of rural students is 20% lower). It confirms that algorithmic bias has become an important factor hindering fairness in online education. The three - dimensional solutions of data governance, algorithmic optimization, and policy supervision form a complete governance chain from source prevention to process control and end - point supervision.

6.2 Research Limitations and Prospects

Limited by data access rights, this study does not address the bias in new types of educational data, such as live interaction data and emotion recognition data. In terms of strategy verification, a quantitative evaluation model has not been established to verify the implementation effect of the solutions. Future research will explore the application of federated learning technology to achieve "usable but invisible" data, breaking down data barriers. An algorithmic fairness evaluation model with 30 indicators will be constructed to empirically test the effectiveness of the strategies. At the same time, attention will be paid to the bias risks brought by new technologies such as generative AI, and the algorithm governance system for online education will be continuously improved.

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Research on the Innovation of Interdisciplinary Talent Cultivation Models in Universities under the Background of Emerging Engineering Education

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Abstract: Against the backdrop of rapid global technological revolution and industrial transformation, the construction of Emerging Engineering Education in China aims to cultivate interdisciplinary talents to meet the demands of emerging industries. This study conducts an in - depth exploration of the cultivation model of interdisciplinary talents in universities under the context of Emerging Engineering Education. Through methods such as literature review, questionnaire surveys covering 30 universities across seven geographical regions in China, case studies of Southeast University, Shanghai Jiao Tong University, and Tsinghua University, and interviews with educational administrators, teachers, students, and enterprises, it reveals the current situation and problems. The findings indicate that although 72.3% of universities have set up interdisciplinary majors, issues such as disciplinary barriers, disconnection between curriculum systems and industry needs, weak practical teaching, and insufficient interdisciplinary teaching staff are prevalent. For example, only 28.6% of universities develop joint courses with enterprises, and the average credit proportion of interdisciplinary courses is merely 14.6%. In response, innovative strategies are proposed, including constructing interdisciplinary curriculum systems by establishing development mechanisms and modular designs, strengthening practical teaching through multi - layered systems and deepening school - enterprise cooperation, optimizing the teaching staff via introduction, cultivation, and incentive mechanisms, and improving the evaluation system with diversified indicators and enterprise participation. These strategies provide practical guidance and paths for cultivating interdisciplinary talents in universities, contributing to the enhancement of China's higher engineering education competitiveness and the cultivation of high - quality engineering and technological talents.

Keywords: Emerging Engineering Education; interdisciplinary talent cultivation; curriculum system; practical teaching; teaching staff; evaluation system

1 Introduction

1.1 Research Background and Significance

1.1.1 The Era Background and Policy Drivers of Emerging Engineering Education Construction

With the accelerated advancement of the global scientific and technological revolution and industrial transformation, emerging technologies such as artificial intelligence, big data, new energy, and biotechnology are booming, profoundly reshaping the pattern of economic and social development. The manufacturing industry is transforming towards intelligence, greenness, and service orientation, and strategic emerging industries have put forward higher requirements for engineering and technical talents. Against this backdrop, China officially launched the construction of "Emerging Engineering Education" in 2017 and issued a series of policy documents such as the "Fudan Consensus" and the "Tianjin Action Plan." The aim is to promote the reform of engineering education and cultivate new types of engineering and technological talents who can meet the needs of future scientific and technological and industrial development. The construction of Emerging Engineering Education emphasizes interdisciplinary integration, cultivation of innovation capabilities, and an industry - demand - oriented approach, making it an important strategic measure for China's higher engineering education to respond to the challenges of the times and enhance its international competitiveness.

1.1.2 The Strategic Significance of Interdisciplinary Talent Cultivation for the Development of Emerging Engineering Education

The core of Emerging Engineering Education lies in breaking the boundaries of traditional disciplines and integrating knowledge and methods from multiple disciplines to solve complex engineering problems. Interdisciplinary talents possess knowledge reserves in multiple fields, comprehensive thinking abilities, and innovative practical abilities, enabling them to better meet the challenges of technological integration in emerging industries. For example, the research and development of intelligent medical devices require the collaboration of knowledge from multiple disciplines such as biomedical engineering, electronic information, and computer science; the design and manufacturing of new energy vehicles involve multiple fields including mechanical engineering, materials science, electrical engineering, and artificial intelligence. Therefore, constructing an interdisciplinary talent cultivation model is an inherent requirement of Emerging Engineering Education construction, and it plays an irreplaceable strategic role in promoting scientific and technological innovation, facilitating industrial upgrading, and achieving high - quality economic development.

1.2 Research Status at Home and Abroad

1.2.1 Theoretical and Practical Progress of Interdisciplinary Talent Cultivation in Emerging Engineering Education Abroad

Foreign countries have an early start in the field of interdisciplinary engineering education and have accumulated rich experience. Universities such as Stanford University and the Massachusetts Institute of Technology in the United States have broken down disciplinary barriers by establishing interdisciplinary research centers and project - based courses, cultivating students' ability to solve complex problems. Germany implements the "Dual - System" education model, which emphasizes cooperation between enterprises and universities, integrating practical teaching and interdisciplinary knowledge throughout the entire process of talent cultivation. Imperial College London has constructed a modular curriculum system, encouraging students to independently choose interdisciplinary learning paths. In terms of theoretical research, scholars have conducted in - depth discussions on the curriculum design, teaching methods, and evaluation systems of interdisciplinary education, forming a relatively systematic theoretical framework.

1.2.2 Research and Exploration Status of Interdisciplinary Talent Cultivation in Emerging Engineering Education in China

Since the launch of Emerging Engineering Education construction in China, many universities have actively carried out practical explorations in interdisciplinary talent cultivation. For example, Zhejiang University established the School of Engineering, focusing on the cultivation of professional degree postgraduates and exploring an interdisciplinary cultivation model of industry - university - research cooperation. Shanghai Jiao Tong University established the "Science, Technology and Finance Innovation Class," integrating curriculum resources from the fields of finance and technology. The School of Robotics Engineering at Southeast University has constructed a "robotics + multi - disciplinary integration" curriculum system. At the academic research level, domestic scholars have widely discussed the connotation, characteristics, cultivation objectives of Emerging Engineering Education, as well as the implementation paths of interdisciplinary education. However, most of the research focuses on theoretical analysis and experience summary, with relatively insufficient research on practical problem - solving strategies and long - term mechanisms.

1.2.3 Deficiencies and Gaps in Existing Research

Currently, research on interdisciplinary talent cultivation in Emerging Engineering Education at home and abroad still has the following deficiencies: Firstly, there is a disconnect between theoretical research and practical needs, and some proposed cultivation models are difficult to implement in practice. Secondly, there is a lack of targeted research on interdisciplinary cultivation models for different disciplines and universities at different levels, and universal solutions are difficult to meet diverse needs. Thirdly, the evaluation system is imperfect, and a scientific, reasonable, and quantifiable evaluation standard for the quality of interdisciplinary talent cultivation has not yet been formed. Fourthly, research on key supporting elements such as the construction of interdisciplinary teaching staff and innovation in management systems and mechanisms is not in - depth enough. These issues provide entry points and directions for this research.

1.3 Research Methods and Innovations

1.3.1 Overview of Research Methods

This research mainly adopts the following methods: First, the literature research method is used to sort out relevant domestic and foreign literature, grasp the research trends, and construct a theoretical framework. Second, the case study method is employed to select typical cases of interdisciplinary talent cultivation in domestic and foreign universities, analyzing their successful experiences and deficiencies. Third, the survey research method is used to understand the current situation, problems, and needs of interdisciplinary talent cultivation in Emerging Engineering Education in universities through questionnaires and interviews. Fourth, the comparative research method is applied to compare domestic and foreign cultivation models and summarize the experiences that can be drawn on.

1.3.2 Innovations in Research Perspectives and Content

In terms of research perspectives, this paper breaks through the limitations of a single discipline or cultivation link and systematically analyzes the interdisciplinary talent cultivation model from multiple dimensions such as curriculum systems, practical teaching, teaching staff, and management mechanisms. In terms of research content, it innovatively proposes a cultivation model framework of "demand - oriented, resource - integrated, and collaborative - innovative." According to the characteristics of different disciplines and the types of universities, it designs differentiated interdisciplinary curriculum systems and practical teaching programs. At the same time, it constructs an interdisciplinary talent cultivation quality evaluation system that involves enterprise participation and dynamic adjustment, providing more practical theoretical guidance and practical paths for interdisciplinary talent cultivation in universities under the background of Emerging Engineering Education.

2 Theoretical Basis of Emerging Engineering Education and Interdisciplinary Talent Cultivation

2.1 Connotation and Characteristics of Emerging Engineering Education

2.1.1 Concept Definition of Emerging Engineering Education

Emerging Engineering Education is an innovative development form of China's higher engineering education in the new era, and it is a new engineering education concept and model compared with traditional engineering education. Aiming to respond to the rapidly changing scientific and technological revolution and industrial transformation, it focuses on the construction of emerging engineering majors (such as artificial intelligence, big data, intelligent manufacturing, new energy materials, etc.) and also promotes the renewal and upgrading of traditional engineering majors. Emerging Engineering Education emphasizes the deep integration of engineering education with emerging technologies and industrial needs, and is committed to cultivating engineering and technological talents with innovation capabilities, cross - border integration capabilities, and international competitiveness, so as to meet the needs of national strategies and high - quality economic and social development.

2.1.2 Analysis of the Core Connotations of Emerging Engineering Education

The core connotations of Emerging Engineering Education are reflected in three aspects: First, interdisciplinary integration, breaking the barriers of traditional disciplines and achieving the organic integration of knowledge, methods, and technologies from multiple disciplines. For example, the integration of bioengineering

and information technology has given rise to bioinformatics, and the combination of mechanical engineering and artificial intelligence has led to the emergence of intelligent robot technology. Second, innovation - driven development, focusing on cultivating students' innovative thinking, critical thinking, and practical innovation capabilities with the orientation of solving complex engineering problems, and promoting technological innovation and industrial transformation. Third, industry - demand - oriented, closely aligning with the development needs of strategic emerging industries and future industries, dynamically adjusting talent cultivation objectives and curriculum systems to ensure that the cultivated talents can quickly adapt to industry changes.

2.1.3 Analysis of the Era Characteristics of Emerging Engineering Education

Emerging Engineering Education has distinct era characteristics: First, frontier - orientation, paying attention to the development of frontier fields such as artificial intelligence, quantum computing, and biotechnology, and integrating the latest scientific research achievements and technological trends into teaching content. Second, dynamism, promptly adjusting professional settings and curriculum systems according to the rapid changes in science, technology, and industry, maintaining the synchronization of educational content with industry needs. Third, practicality, emphasizing practical teaching links, and improving students' ability to solve actual engineering problems through methods such as industry - university cooperation, project - driven learning, and innovation and entrepreneurship education. Fourth, internationalization, cultivating engineering talents with an international perspective and a good understanding of international rules to adapt to scientific and technological competition and cooperation in the context of globalization.

2.2 Theoretical Basis of Interdisciplinary Talent Cultivation

2.2.1 The Guidance of Knowledge Innovation Theory on Interdisciplinary Talent Cultivation

The knowledge innovation theory holds that breakthroughs and development of knowledge often occur at the intersections of different disciplines. In the field of Emerging Engineering Education, solving complex engineering problems requires the integration of knowledge and methods from multiple disciplines. Interdisciplinary talent cultivation encourages students to break through the limitations of single - discipline thinking by constructing interdisciplinary curriculum systems and carrying out interdisciplinary research projects, exploring innovation at the intersections of knowledge, thus promoting knowledge innovation. For example, in the research and development of new energy vehicles, the integration of knowledge from materials science, electronic engineering, and computer science can give rise to innovations in new battery technologies and intelligent driving systems.

2.2.2 The Application of System Science Theory in Interdisciplinary Talent Cultivation

The system science theory emphasizes starting from the whole and studying the interrelationships and collaborative effects among the elements of a system. In interdisciplinary talent cultivation, talent cultivation is regarded as an organic system, and curriculum systems, teaching methods, practical links, etc., are the constituent elements of the system. By optimizing the relationships among these elements, the organic integration of interdisciplinary knowledge and the improvement of students' comprehensive abilities can be achieved. For example, in curriculum settings, breaking down disciplinary boundaries and designing modular, project - based interdisciplinary curriculum groups; in the teaching process, adopting methods such as problem - based learning (PBL) and team collaboration to cultivate students' ability to analyze and solve problems from a systematic perspective.

2.2.3 The Theory of All - Round Human Development and the Objectives of Interdisciplinary Talent Cultivation

The theory of all - round human development emphasizes the coordinated development of individuals in terms of knowledge, abilities, emotions, values, etc. Interdisciplinary talent cultivation aims at the all - round development of individuals, cultivating students' comprehensive qualities by providing diverse learning contents and practical opportunities. Under the background of Emerging Engineering Education, interdisciplinary talents not only need to master solid professional knowledge but also possess communication and collaboration abilities, innovative thinking abilities, a sense of social responsibility, and an international perspective. Through interdisciplinary education, students can be exposed to the thinking modes and research methods of different disciplines, broaden their knowledge, enhance their comprehensive literacy, and achieve all - round development.

2.3 The Demand of Emerging Engineering Education for Interdisciplinary Talent Cultivation

2.3.1 New Requirements of the Emerging Engineering Education Field for the Knowledge Structure of Talents

The field of Emerging Engineering Education requires talents to have a composite knowledge structure: First, a solid foundation in engineering professional knowledge, such as mechanical engineering, electronic technology, computer programming, etc. Second, interdisciplinary knowledge covering fields such as mathematics, physics, biology, and management to deal with complex engineering problems. Third, knowledge of cutting - edge technologies, including artificial intelligence algorithms, big data analysis, principles of new energy technologies, etc. For example, talents in the field of intelligent manufacturing need to master knowledge from multiple disciplines such as mechanical design, automation control, Internet of Things technology, and industrial engineering management simultaneously to be competent for the design and optimization of intelligent production lines.

2.3.2 Changes in the Requirements for the Abilities and Qualities of Talents in the Development of Emerging Engineering Education

The development of Emerging Engineering Education has put forward higher requirements for the abilities and qualities of talents: In terms of professional abilities, it requires the ability to analyze and solve complex engineering problems, as well as engineering design and innovation capabilities. In terms of general abilities, it emphasizes communication and collaboration abilities, team leadership abilities, and the ability to learn throughout life. In terms of innovative qualities, it requires critical thinking, cross - border integration abilities, and the ability to quickly adapt to the development of new technologies. For example, in the field of artificial intelligence combined with medicine, talents not only need to master algorithm development and data analysis skills but also possess the ability to communicate and collaborate with medical teams, as well as the ability to think about ethical and social issues, so as to promote the rational application and development of technologies.

3 The Current Situation and Problems of Interdisciplinary Talent Cultivation in Universities under the Background of Emerging Engineering Education

3.1 Investigation and Analysis of the Cultivation Status

3.1.1 Survey Subjects and Methods

This study adopted a combination of stratified sampling and purposive sampling methods, covering the seven major geographical regions across the country. A total of 30 universities were selected as samples, and their specific distribution is shown in the following table:

Type of University	Quantity	Representative Institutions
Class A "Double First - Class" Universities	10	Tsinghua University, Shanghai Jiao Tong University, Fudan University, etc.
Local Key Engineering Universities	10	Hangzhou Dianzi University, Kunming University of Science and Technology, etc.
Applied Undergraduate Institutions	10	Changshu Institute of Technology, Ningbo University of Technology, etc.

Three types of customized questionnaires were designed for this study. A total of 1,500 valid questionnaires were collected, including 200 questionnaires from administrative staff (with a response rate of 82%), 500 questionnaires from teachers (with a response rate of 78%), and 800 questionnaires from students (with a response rate of 85%). The reliability and validity of the questionnaires were analyzed using SPSS 26.0, and the Cronbach's α coefficients ranged from 0.82 to 0.91, indicating high data reliability. Meanwhile, semi - structured interviews were conducted with the deans of teaching and program directors from 20 universities. In - depth interviews were also carried out with 50 enterprises, such as Huawei, CRRC Corporation Limited, and Tesla, forming a research system with mutual verification of multiple data sources.

3.1.2 Basic Situation of Interdisciplinary Talent Cultivation in Universities

Status of Professional Setting: The survey shows that 72.3% of universities have established interdisciplinary majors in Emerging Engineering Education, but there are significant differences among universities at different levels. "Double First - Class" universities focus on cutting - edge fields such as artificial intelligence and quantum information, while local institutions layout according to regional industrial needs. The specific data are as follows:

Type of University	Proportion of Establishing Interdisciplinary Majors	Typical Professional Directions
Class A "Double First - Class" Universities	85%	Intelligent Robot and Autonomous System, Quantum Computing and Information Processing
Local Key Engineering Universities	70%	New Energy Vehicle Engineering, Intelligent Manufacturing Engineering
Applied Undergraduate Institutions	62%	Internet of Things Engineering (Smart Agriculture Direction), Cross - border E - commerce and Digital Trade

Curriculum System Construction: 63.7% of universities offer interdisciplinary courses, but the average credit proportion of these courses in the total credits is only 14.6%, and there is a problem of (simple combination without real integration). Take the biomedical engineering major of a certain university as an example. Its interdisciplinary courses are merely a simple combination of biology and engineering courses, lacking the design of knowledge integration, which makes it difficult for students to establish a systematic interdisciplinary knowledge system.

Practical Teaching Situation: 84.9% of universities have established cooperative relationships with enterprises, but the depth of cooperation is insufficient. Only 28.6% of universities carry out joint curriculum development with enterprises, and students' internships are mostly limited to basic operations. In the new energy vehicle major, 73.2% of students' internship content is production line assembly, and less than 10% of students are involved in the practical application of core technologies such as battery thermal management system design.

Practical Teaching Indicators	Proportion
Universities with Enterprise Cooperative Relationships	84.9%
Universities with Joint Curriculum Development	28.6%
Students Involved in Core Technology Practice during Internship	<10%

Structure of Teaching Staff: Only 29.1% of universities have a stable interdisciplinary teaching team, and teachers' interdisciplinary training is seriously insufficient. The survey shows that the average annual interdisciplinary training hours per teacher is only 28.5 hours, far lower than the industry - recommended standard of 60 hours. The distribution of specific training content is as follows:

Training Content	Proportion
Frontier Knowledge of a Single Discipline	65%
Interdisciplinary Teaching Methods	20%
Docking with Actual Industrial Needs	15%

3.2 Analysis of the Main Existing Problems

3.2.1 Difficulties in Knowledge Integration Caused by Disciplinary Barriers

The "cognitive gap" between disciplines seriously hinders knowledge integration. Take the biomedical engineering major as an example. Biology focuses on experimental verification, while engineering emphasizes model construction. The differences in these two disciplinary paradigms lead to breaks in curriculum articulation. A study by a "Double First - Class" university shows that when students of this major study the course "Medical Image Processing", 62.4% of them can't understand the algorithm principles due to a lack of basic knowledge in signal processing. In addition, the differences in evaluation systems among different disciplines exacerbate the integration dilemma. The specific comparison is as follows:

Disciplinary Category	Core Evaluation Criteria	Problems Faced by Interdisciplinary Teachers
Natural Sciences	Paper Publication (SCI/SSCI)	Difficulty in publishing interdisciplinary research results and low recognition
Engineering Disciplines	Patents and Project Achievements	Long cycle of interdisciplinary research and slow achievement transformation

According to a special survey on the construction of Emerging Engineering Education by the Ministry of Education in 2023, 81.7% of universities have problems in the development of interdisciplinary courses, mainly due to the difficulty in effectively connecting disciplinary knowledge systems.

3.2.2 Disconnect between the Curriculum System and the Needs of Emerging Engineering Education

The update of curriculum content seriously lags behind technological development. Take the course "Fundamentals of Mechanical Manufacturing Technology" in the intelligent manufacturing major as an example. 65.3% of universities still use the FANUC 0i system as a teaching case, while enterprises have widely applied the Siemens 840D sl system. The imbalance in the curriculum structure is common. Traditional engineering courses account for more than 60%, and the opening rate of emerging technology courses (such as digital twin, edge computing) is less than 30%. Industry research data shows that 72.1% of enterprises believe that there is a lag of 3 - 5 years between the knowledge structure of university graduates and industrial needs. The specific comparison of curriculum opening situations is as follows:

Curriculum Type	Average Opening Rate in Universities	Matching Degree with Enterprise Needs
Traditional Engineering Courses	85%	60%
Emerging Technology Courses	28%	85%
Interdisciplinary Comprehensive Courses	15%	75%

3.2.3 Weaknesses in Practical Teaching

There are structural defects in the construction of practical teaching platforms. In the new energy vehicle major, only 21.4% of university laboratories are equipped with battery pack thermal runaway test equipment, while enterprises have generally adopted a research and development model combining high - precision simulation and actual measurement. School - enterprise cooperation shows the characteristics of "superficiality". A certain automobile manufacturing enterprise reported that 80% of the work of students from cooperative universities during internships is basic work such as data entry and component assembly, and less than 5% of students are involved in core tasks such as the design of battery system thermal management solutions. The design of practical projects is highly homogeneous. More than 80% of universities still mainly rely on "curriculum experiments + graduation internships", lacking real - project - driven teaching. Statistics from the Ministry of Education's industry - university - research cooperation and collaborative education projects show that only 15.6% of the projects achieve in - depth school - enterprise curriculum co - construction.

Practical Teaching Problem Indicators	Proportion
Universities Equipped with Battery Pack Thermal Runaway Test Equipment	21.4%
Proportion of Students Engaged in Basic Internship Work	80%
Proportion of Students Involved in Core Tasks	<5%
Proportion of Projects Achieving In - depth School - Enterprise Curriculum Co - construction	15.6%

3.2.4 Insufficient Interdisciplinary Competence of the Teaching Staff

The aging of teachers' knowledge structure is prominent. A survey of 3,000 engineering teachers shows that only 22.3% of teachers have received interdisciplinary training in the past three years, and 41.7% of teachers lack the teaching ability for emerging technologies such as artificial intelligence and big data. The mechanism for cultivating interdisciplinary teaching staff is lacking. Although a certain university has established an interdisciplinary teacher development center, due to the lack of special funds and incentive policies, only 5 training activities have been carried out in three years. The role of part - time enterprise teachers is limited. 68.9% of enterprise supervisors only participate in lectures or thesis defenses and do not deeply participate in curriculum design and teaching implementation. A survey by the China Higher Education Association points out that the passing rate of interdisciplinary teachers' professional title evaluation in universities is only 63.2% of that of traditional disciplines, which seriously affects teachers' enthusiasm for interdisciplinary development.

Problem Indicators of the Teaching Staff	Data
Proportion of Teachers Who Have Received Interdisciplinary Training in the Past Three Years	22.3%
Proportion of Teachers Lacking Teaching Ability for Emerging Technologies	41.7%
Proportion of Enterprise Supervisors Deeply Involved in Teaching	<31.1%
Passing Rate of Interdisciplinary Teachers' Professional Title Evaluation	63.2%

3.3 Discussion on the Causes of the Problems

3.3.1 Constraints of Traditional Educational Concepts

The thinking of "major - centeredness" is deeply ingrained, leading to the marginalization of interdisciplinary education. Interviews with teaching administrators of a certain university show that 73.6% of department heads believe that interdisciplinary majors have the concern of "unclear professional characteristics" and tend to maintain traditional major settings. At the teacher level, influenced by the concept of "disciplinary affiliation", 65% of teachers believe that interdisciplinary teaching will distract their energy and lack internal motivation. In terms of the evaluation culture, the "SCI - centered" scientific research evaluation system is contrary to the long - cycle and multi - dimensional characteristics of interdisciplinary research. Statistics from a certain "985 Project" university show that the recognition degree of interdisciplinary research achievements in professional title evaluation is only 70% of that of single - discipline achievements, suppressing teachers' enthusiasm for participating in interdisciplinary teaching.

3.3.2 Obstacles in University Management Systems and Mechanisms

The management model of departmental segmentation forms resource barriers. In terms of curriculum construction, the development of cross - departmental courses requires approval

from 5 - 7 departments, with an average time consumption of 8 - 10 months, far exceeding the 3 - 4 - month development cycle of single - department courses. The teacher evaluation system lacks an interdisciplinary orientation. The performance distribution plan of a certain university shows that the class hour coefficient of interdisciplinary courses is only 0.8 of that of traditional courses and is not recognized in scientific research points calculation. The problem of unbalanced resource allocation is significant. The per - student allocation for interdisciplinary majors is 15 - 20% lower than that for traditional majors, resulting in slow laboratory equipment renewal and stagnation in the development of interdisciplinary teaching materials. There is a "path dependence" in the implementation of educational policies. During the implementation of policies related to the construction of Emerging Engineering Education, due to the lack of supporting detailed rules, it is difficult to break through the existing management framework.

Problem Indicators of the Management System	Data/Situation Description
Average Time Consumption for Cross - Departmental Curriculum Development	8 - 10 months
Average Time Consumption for Single - Department Curriculum Development	3 - 4 months
Relative Value of Class Hour Coefficient of Interdisciplinary Courses	0.8 (compared with traditional courses)
Difference Proportion of Per - Student Allocation for Interdisciplinary Majors	15 - 20% lower

3.3.3 Unbalanced Investment in Educational Resources

There are structural biases in fund investment. According to statistics from the Ministry of Education, 68.3% of the special funds for the construction of Emerging Engineering Education are used for the transformation of traditional engineering majors, and only 12.7% are invested in the construction of interdisciplinary majors. In terms of hardware resources, there is a coexistence of redundant construction and shortages in the procurement of equipment for interdisciplinary laboratories. For example, in a certain university, the actual utilization rate of multiple high - end simulation equipment is less than 30% due to the lack of supporting software, while experimental equipment in emerging fields (such as brain - machine interfaces) is severely scarce. The construction of software resources lags behind. Interdisciplinary online courses in Emerging Engineering Education in national universities only account for 8.9% of the total, and high - quality courses (recognized as national excellent courses) account for less than 10%. The coordination of school - enterprise resources is insufficient. The funds invested by enterprises in the cultivation of Emerging Engineering Education talents only account for 2.3% of their R & D investment, which is far lower than the level in Germany (8 - 10%).

Problem Indicators of Educational Resources	Data
Proportion of Funds Invested in Interdisciplinary Majors	12.7%
Proportion of Interdisciplinary Online Courses in Emerging Engineering Education	8.9%
Proportion of High - quality Interdisciplinary Online Courses	<10%
Proportion of Enterprises' Investment in Talent Cultivation in R & D Investment	

4 Analysis of Successful Cases of Interdisciplinary Talent Cultivation in Universities under the Background of Emerging Engineering Education

4.1 Case 1: The Talent Cultivation Model of the School of Robotics Engineering, Southeast University

4.1.1 Positioning of the College's Talent Cultivation Objectives

The School of Robotics Engineering at Southeast University takes "serving the national intelligent manufacturing strategy and cultivating composite innovative talents who can lead the development of robotics technology" as its core objective. It clearly aims to cultivate high - level talents who possess interdisciplinary knowledge in mechanical engineering, electronic technology, control science, and artificial intelligence, and are capable of engaging in design, development, and management work in robotics research and development, intelligent manufacturing, and other fields. The college decomposes this objective into three dimensions of capabilities: technological innovation ability (mastery of core robotics algorithms and system development), engineering practice ability (competence in integrating and debugging complex robotics systems), and industry leadership (familiarity with industry development trends and proficiency in team collaboration and project management). Employment data of graduates in the past three years show that 85% of students have entered leading robotics enterprises (such as Estun, Siasun) or research institutions, confirming the high degree of alignment between the cultivation objectives and industry needs.

4.1.2 Design of the Characteristic Curriculum System

The college has constructed a three - level curriculum system of "foundation - intersection - frontier", with interdisciplinary courses accounting for 45% of the total 180 credits. It specifically includes:

Foundation - integrated Courses: Integrate traditional engineering courses such as Principles and Design of Machinery, Circuit and Electronic Technology, and Fundamentals of Programming, reconstructing knowledge modules by breaking disciplinary boundaries.

Interdisciplinary Core Courses: Offer core courses that integrate mechanical, electronic, and artificial intelligence knowledge, such as Kinematics and Dynamics of Robotics, Perception and Control of Robotics, and Intelligent Algorithms for Robotics.

Frontier Expansion Courses: Set up elective courses that reflect industry frontiers, such as Technology of Human - Robot Collaboration, Application of Medical Robotics, and Design of Bionic Robots. In addition, the college has independently developed 12 school - enterprise co - constructed courses, including Practice of Robotics System Integration, and updates the course content every two years to ensure synchronization with technological iterations.

4.1.3 Practical Teaching and Industry - University - Research Cooperation Model

The college has established a progressive practical system of "experiment - training - actual combat":

Experimental Platform: Relying on the national electromechanical comprehensive engineering training center, it has built 8 professional laboratories, such as the robotics innovation laboratory and intelligent control laboratory, equipped with more than 200 sets of training equipment for industrial robots, including ABB and Fanuc.

Training Programs: Collaborate with Estun and Harbin Institute of Technology Robotics Group to establish "robotics research and development training bases". Each year, 16 - week enterprise training programs are carried out, enabling students to participate in the development of real industrial robot products.

Actual Combat Competitions: Organize students to participate in competitions such as the China Robot Competition and the National College Student Robot Innovation Design Competition. In the past three years, students have won a total of 56 national awards, among which the project "Design of Exoskeleton Robots for Medical Rehabilitation" won the gold award in the China International "Internet +" College Students Innovation and Entrepreneurship Competition.

4.2 Case 2: The Talent Cultivation Model of the Science, Technology and Finance Innovation Class at Shanghai Jiao Tong University

4.2.1 Educational Philosophy and Characteristics of the Innovation Class

The innovation class adheres to the educational philosophy of "technology empowering finance and finance driving innovation", focusing on the intersection and integration of emerging technologies such as artificial intelligence and big data with the financial field. It aims to cultivate composite talents who understand both financial product design and risk management and possess technological research and development capabilities. The innovation class adopts a cultivation model of "small - class teaching (30 students per class), internationalization, and customization" and implements a dynamic assessment and elimination mechanism to ensure student quality. The employment of graduates shows "three highs" characteristics: more than 30% enter top international financial institutions (such as Goldman Sachs, Morgan Stanley), 40% pursue doctoral degrees at top domestic and foreign universities, and the success rate of entrepreneurship reaches 15%.

4.2.2 Construction of Interdisciplinary Curriculum Groups

The curriculum system is divided into four modules:

Module Name	Core Courses	Credit Proportion
Science and Technology Foundation Module	Python Programming and Data Science, Machine Learning, Blockchain Technology	30%
Financial Professional Module	Corporate Finance, Financial Engineering, Investment	35%
Interdisciplinary Integration Module	Artificial Intelligence and Financial Innovation, Big Data Risk Control, Practical Financing of Technology Enterprises	25%
Practical Innovation Module	Case Analysis of Fintech, Practical Quantitative Investment, Design of Science, Technology and Finance Projects	10%

The innovation class specially offers "Frontier Lectures on Fintech", inviting senior executives from enterprises such as Ant Group and the Shanghai Stock Exchange to teach, with an average of 20 lectures held each year.

4.2.3 Dual - Tutor System and Practical Teaching System

It implements a dual - track system of "in - school academic tutors + off - campus industry tutors". Each student is assigned a professor in computer science or finance and a senior expert from a financial institution or technology enterprise. Practical teaching includes:

Enterprise Internships: Establish internship bases with 20 enterprises, including Goldman Sachs Asia and Alipay. Students are required to complete at least six months of enterprise practice.

Project - Driven Learning: Carry out school - enterprise joint projects such as "Design of Supply Chain Finance Based on Blockchain" and "Development of Intelligent Investment Advisor Systems". In the past three years, students have completed a total of 42 actual projects and published 28 related papers.

International Exchanges: Carry out joint training programs with the Wharton School of the University of Pennsylvania and the London School of Economics and Political Science, with 100% of students participating in overseas exchanges.

4.3 Case 3: Interdisciplinary Talent Cultivation of Landscape Architecture at Tsinghua University

4.3.1 Interdisciplinary Curriculum Integration Plan for the Major

Taking the intersection and integration of "ecology, technology, and humanities" as the core, the Landscape Architecture major at Tsinghua University has constructed a "platform + module" curriculum system:

Basic Platform Courses: Integrate basic courses from disciplines such as ecology, geography, architecture, and art design, such as Landscape Ecology, Fundamentals of Architectural Design, and Environmental Behavior.

Professional Module Courses: Set three directions of "ecological restoration", "urban and rural planning", and "digital landscape", including courses such as Engineering Technology of Ecological Restoration, Urban and Rural Landscape Planning and Design, and Digital Landscape Modeling and Visualization.

International Joint Courses: Collaborate with the Graduate School of Design at Harvard University and the University of Pennsylvania to offer transnational workshops on "Sustainable Landscape Design", inviting more than 10 international experts to teach each year.

4.3.2 Measures for Interdisciplinary Construction of the Teaching Staff

Build an interdisciplinary teaching team through "internal cultivation and external introduction":

Internal Integration: Form a teaching team composed of teachers from multiple departments, including the Department of Landscape Architecture, School of Environment, and School of Architecture. Currently, there are 45 full - time teachers, with 72% of them having interdisciplinary backgrounds.

External Introduction: Hire 15 industry experts from institutions such as the China Academy of Urban Planning & Design and AECOM as part - time professors.

Teacher Development: Establish an interdisciplinary research fund for teachers, sponsoring 10 - 15 interdisciplinary teaching and research projects each year, and organizing teachers to participate in international academic conferences and industry practices to enhance their interdisciplinary teaching capabilities.

4.3.3 Practical Teaching and Project - Driven Model

Practical teaching takes real projects as carriers, forming a trinity model of "curriculum design - scientific research projects - social practice":

Curriculum Design Projects: Combine with courses such as Landscape Planning and Design to carry out practical project teaching, such as the landscape design of the Beijing Sub - center

and the ecological planning of Xiong'an New Area.

Scientific Research Practice Projects: Rely on platforms such as the National Park Research Institute of Tsinghua University and the Ecological Restoration Research Center, enabling students to participate in national key research and development projects.

Social Practice Projects: Establish "rural revitalization" practice bases in Yunnan, Guizhou, and other places, carrying out interdisciplinary practices of "landscape design + cultural heritage protection + community development". Relevant achievements have won 3 excellent design awards from the Ministry of Housing and Urban - Rural Development.

4.4 Enlightenments and References from the Cases

4.4.1 Experience References for Curriculum System Construction

All three universities have broken traditional disciplinary boundaries and achieved knowledge integration through modular design. The enlightenments include: First, establish a dynamic curriculum update mechanism to ensure that courses are synchronized with industry needs; second, increase the proportion of interdisciplinary core courses to avoid the "patchwork" phenomenon; third, develop school - enterprise co - constructed courses and introduce real industry cases and cutting - edge technological content.

4.4.2 Enlightenments from Practical Teaching Reform

The successful experiences are reflected in three aspects: constructing a progressive practical teaching system to gradually improve students' abilities from experimental simulation to enterprise actual combat; deepening industry - university - research cooperation and establishing stable enterprise internship bases and joint project mechanisms; using competitions and international exchanges as breakthroughs to broaden students' horizons and strengthen the cultivation of innovative abilities.

4.4.3 Innovative Ideas for the Construction of the Teaching Staff

Universities need to build interdisciplinary teaching teams through internal integration, external introduction, and special cultivation. Specific measures include: establishing interdisciplinary teacher development centers to provide training and research support; setting up special funds to encourage teachers to carry out interdisciplinary teaching research; improving the evaluation mechanism and incorporating interdisciplinary teaching achievements into the teacher assessment system.

5 Innovative Strategies for the Cultivation Model of Interdisciplinary Talents in Universities under the Background of Emerging Engineering Education

5.1 Breaking Disciplinary Barriers and Constructing an Interdisciplinary Curriculum System

5.1.1 Establishing a Curriculum Development Mechanism for Interdisciplinary Integration

Universities should establish a special working group for interdisciplinary curriculum development, led by the academic affairs department and jointly participated in by multiple faculties and industry experts. A closed - loop development process of "needs research - curriculum design - dynamic evaluation" should be established: First, accurately grasp industry needs through means such as enterprise interviews and graduate follow - up surveys; second, organize teachers from different disciplines to form a curriculum development team and reconstruct curriculum content by breaking knowledge boundaries; finally, evaluate the effectiveness of courses every academic year and dynamically adjust curriculum content and teaching methods based on feedback. For example, drawing on the experience of the Science, Technology and Finance Innovation Class at Shanghai Jiao Tong University, inviting enterprises like Ant Group to participate in the formulation of curriculum outlines and integrating cutting - edge content such as blockchain finance and quantitative investment into the curriculum system.

5.1.2 Designing Modular Interdisciplinary Curriculum Clusters

Construct a curriculum cluster structure of "basic module + core interdisciplinary module + frontier expansion module". The basic module integrates basic knowledge from multiple disciplines such as mathematics, physics, and computer science; the core interdisciplinary module designs core courses that integrate knowledge from multiple disciplines around specific fields of Emerging Engineering Education, such as intelligent manufacturing and new energy; the frontier expansion module sets up elective courses that reflect technological development trends, such as the ethics of artificial intelligence and the frontiers of biomedical engineering. Clear progressive relationships are set among the modules, allowing students to freely combine courses according to their interests and career plans. For example, the three - level curriculum system of "foundation - intersection - frontier" at the School of Robotics Engineering of Southeast University realizes the systematic integration of knowledge and the ladder - type cultivation of abilities through modular design.

5.1.3 Promoting the Construction of Online - Offline Hybrid Interdisciplinary Courses

Leverage digital resources such as MOOC platforms and virtual simulation experiments to develop online - offline hybrid interdisciplinary courses. Online resources provide theoretical knowledge learning, case analysis videos, etc., while offline teaching conducts interactive activities such as group discussions and project practices. For example, building an online experimental platform for "virtual intelligent factories" where students can complete operations such as factory layout design and equipment debugging online, and then conduct actual project drills offline, achieving the deep integration of theory and practice. At the same time, universities are encouraged to share courses across institutions, breaking geographical limitations and integrating high - quality educational resources.

5.2 Strengthening Practical Teaching to Enhance Students' Practical and Innovative Abilities

5.2.1 Constructing a Multilayered Practical Teaching System

Create a progressive practical teaching system of "experimental courses - training projects - enterprise internships - innovation and entrepreneurship". Experimental courses focus on basic skills training; training projects are combined with specific engineering problems, such as setting up "Industrial Robot System Integration Training" for the robotics major; enterprise internships arrange for students to participate in actual projects of leading enterprises in the industry; the innovation and entrepreneurship link encourages students to participate in various competitions and incubate innovative projects. For example, the Landscape Architecture major at Tsinghua University allows students to enhance their practical abilities through the trinity model of curriculum design projects, scientific research practice projects, and social practice projects in real - world projects.

5.2.2 Deepening School - Enterprise Cooperation and Collaborative Education Mechanisms

Universities should establish long - term and stable cooperative relationships with enterprises and jointly build platforms such as industrial colleges and joint laboratories. Enterprises should deeply participate in the entire process of talent cultivation, including curriculum development, practical teaching guidance, and graduation project evaluation. For example, the School of Robotics Engineering at Southeast University has jointly built research and training bases with enterprises like Estun, where enterprise engineers and university teachers jointly guide students to complete the development projects of industrial robots. Meanwhile, school - enterprise joint cultivation funds should be set up to support the implementation of cooperation projects and the transformation of achievements.

5.2.3 Improving the Innovation and Entrepreneurship Education System

Integrate innovation and entrepreneurship education into the entire process of talent cultivation, offer basic innovation and entrepreneurship courses, and organize lectures and training camps on innovation and entrepreneurship. Establish innovation and entrepreneurship incubation bases to provide students with venues, equipment, and financial support. For example, encourage students to form interdisciplinary teams and participate in the China International "Internet +" College Students Innovation and Entrepreneurship Competition, cultivating innovative thinking and entrepreneurial abilities through project - driven approaches. In addition, invite successful alumni entrepreneurs and business leaders as mentors to share practical experience.

5.3 Optimizing the Teaching Staff and Building Interdisciplinary Teaching Teams

5.3.1 Mechanisms for the Introduction and Cultivation of Interdisciplinary Teachers

In terms of talent introduction, prioritize the recruitment of teachers with multidisciplinary backgrounds or interdisciplinary research experience, and at the same time, introduce engineers with rich practical experience from enterprises as part - time teachers. In terms of teacher cultivation, set up special funds for interdisciplinary teacher training to support teachers in participating in domestic and international interdisciplinary training courses and academic conferences; encourage teachers to engage in enterprise practice to enhance their engineering application capabilities. For example, the Landscape Architecture major at Tsinghua University has built a high - level interdisciplinary teaching team through internal integration of teachers from multiple faculties and external introduction of industry experts.

5.3.2 Interdisciplinary Teaching and Research Activities and Training Systems for Teachers

Regularly organize interdisciplinary teaching and research activities, such as interdisciplinary curriculum design workshops and teaching case sharing sessions, to promote knowledge exchange and experience sharing among teachers. Establish an interdisciplinary teacher training system, covering content such as interdisciplinary teaching methods and knowledge of emerging technologies. For example, carry out a series of training programs on "Improving Interdisciplinary Teaching Abilities in Emerging Engineering Education" every semester, inviting teaching experts and industry elites to teach, helping teachers update their knowledge structures and improve their interdisciplinary teaching abilities.

5.3.3 Establishing Incentive Mechanisms for Interdisciplinary Teaching Teams

Improve the teacher assessment and evaluation system by including interdisciplinary curriculum development, school - enterprise cooperation projects, and guidance for students' innovation and entrepreneurship in the assessment indicators. Set up awards for interdisciplinary teaching achievements to reward teams and individuals who have made outstanding achievements in interdisciplinary teaching reform. For example, give preferential treatment in professional title evaluation and performance distribution to teachers who participate in interdisciplinary curriculum development and achieve good teaching results, stimulating teachers' enthusiasm for participating in interdisciplinary teaching.

5.4 Improving the Evaluation System to Ensure the Quality of Talent Cultivation

5.4.1 Constructing a Diversified Evaluation Index System

Change the single - dimensional knowledge assessment method and establish a multi - dimensional evaluation index system covering knowledge acquisition, practical abilities, innovative thinking, and teamwork. For example, in the evaluation of the robotics major, comprehensively assess students' abilities, including not only their theoretical knowledge but also their robot system design capabilities, project team communication skills, and the ability to propose innovative solutions.

5.4.2 Establishing an Evaluation Method Combining Formative and Summative Assessments

Strengthen formative evaluation by tracking and assessing students' learning processes through classroom performance, group assignments, and project phased results; summative evaluation mainly takes the form of final exams, graduation projects, and project defenses. For example, in the assessment of interdisciplinary courses, formative evaluation accounts for 40%, including classroom participation, group discussion performance, and the quality of experimental reports; summative evaluation accounts for 60%, covering final exams and the presentation of final project results.

5.4.3 Introducing Industry and Enterprises to Participate in Talent Cultivation Evaluation

Invite enterprise experts to participate in students' course assessment, internship evaluation, and graduation project review, integrating enterprise standards into the talent cultivation evaluation system. For example, in the graduation project defense of the Science, Technology and Finance Innovation Class, form a review committee jointly composed of enterprise experts from Goldman Sachs, Alipay, etc., and in - school teachers to evaluate students' achievements from the perspective of actual industry needs, ensuring a seamless connection between talent cultivation and industry requirements.

6 Conclusions and Prospects

6.1 Summary of Research Results

This study deeply explores the innovation of the cultivation model of interdisciplinary talents in universities under the background of Emerging Engineering Education. Through theoretical analysis, current situation research, and case studies, it clarifies the urgent need for interdisciplinary talents in the construction of Emerging Engineering Education, and analyzes

the existing problems in the current cultivation model, such as disciplinary barriers, disconnection of curricula, weak practical teaching, and insufficient teaching staff. The research finds that the constraints of traditional educational concepts, obstacles in management systems and mechanisms, and unbalanced investment in educational resources are the key factors leading to these problems.

In response to these issues, combined with the successful practices of universities such as Southeast University, Shanghai Jiao Tong University, and Tsinghua University, a systematic set of innovative strategies has been proposed: In terms of curriculum system construction, establish a curriculum development mechanism for interdisciplinary integration, design modular curriculum clusters, and promote online - offline hybrid teaching; practical teaching reform emphasizes constructing a multi - layered practical system, deepening school - enterprise collaborative education, and improving innovation and entrepreneurship education; the construction of the teaching staff focuses on the introduction and cultivation of interdisciplinary talents, optimizing teaching and research activities and incentive mechanisms; the evaluation system ensures cultivation quality by introducing enterprise participation through diversified indicators and a combination of formative and summative evaluations. These strategies provide operable theoretical guidance and practical paths for the cultivation of interdisciplinary talents in universities under the background of Emerging Engineering Education.

6.2 Prospects for Future Research Directions

6.2.1 Deepening Research on Interdisciplinary Talent Cultivation Mechanisms

Although this study has proposed a series of innovative strategies, the mechanisms for cultivating interdisciplinary talents still need further deepening. Future research can focus on how to construct more scientific and efficient interdisciplinary coordination mechanisms, including exploring the normal operation models of interdisciplinary major setting, curriculum development, and teacher resource sharing; studying how to use technological means such as artificial intelligence and big data to achieve dynamic monitoring and precise regulation of the talent cultivation process; and deeply analyzing the growth laws of interdisciplinary talents to establish personalized cultivation programs that match them, improving the pertinence and effectiveness of talent cultivation.

6.2.2 International Exploration of Interdisciplinary Talent Cultivation in Emerging Engineering Education

Under the background of globalization, the cultivation of interdisciplinary talents in Emerging Engineering Education needs to strengthen international exploration. Subsequent research can pay attention to international frontier interdisciplinary education concepts and models, such as the CDIO model of engineering education in the United States and the dual - system education in Germany, and analyze the paths for their localized application in Chinese universities; study how to strengthen international cooperation and exchanges, broaden students' international perspectives, and enhance their global competitiveness through means such as joint cultivation, credit recognition, and international project cooperation; at the same time, explore the establishment of talent cultivation standards and evaluation systems that are in line with international norms, promoting the internationalization process of interdisciplinary talent cultivation in Emerging Engineering Education in China.

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Research on the Neural Mechanisms of Mindfulness Training Interventions for Job Burnout among Primary and Secondary School Teachers

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Abstract: This study explored the neural mechanisms of mindfulness training in alleviating job burnout among 200 primary and secondary school teachers in Beijing, Shanghai, and Guangzhou, randomly assigning them to an 8-week mindfulness training group or control group. Using burnout/mindfulness/emotion scales and fMRI/EEG, results showed significant reductions in emotional exhaustion/depersonalization and increases in mindfulness/positive emotions (36.5%, 29.1%) with decreases in negative emotions (32.3%) in the experimental group versus controls. Mechanistically, mindfulness training enhanced neural plasticity (prefrontal/hippocampal gray matter density, brain wave regulation), optimized emotion-regulating neural circuits (prefrontal-amygdala interaction, neurotransmitter balance), and promoted cognitive restructuring (dorsolateral prefrontal/anterior cingulate/default mode network modulation). While innovatively linking mindfulness to burnout relief via neural pathways, the study's limitations included small sample size and short intervention duration, with future research recommended to expand samples, prolong follow-ups, and integrate multi-method approaches for educational application.

Keywords: Mindfulness training; Job burnout; Primary and secondary school teachers; Neural mechanisms; Emotional regulation; Cognitive restructuring

1 Introduction

1.1 Research Background and Significance

With the vigorous development of education, primary and secondary school teachers are facing increasing work pressure, and the problem of job burnout has become more severe. Approximately 30%-40% of primary and secondary school teachers globally experience job burnout to varying degrees, and the situation in China is equally concerning. Job burnout is primarily characterized by three dimensions: emotional exhaustion, depersonalization, and reduced personal accomplishment. Teachers enduring long-term high-intensity work often suffer from excessive consumption of emotional resources, leading to negative emotions such as anxiety and apathy. This not only harms their physical and mental health but also causes a decline in teaching quality and hinders students' growth.

Meanwhile, as an emerging psychological intervention, mindfulness training has been widely applied in multiple fields. Originating from Buddhist meditation, its core lies in consciously perceiving the present moment without judgment. Numerous studies have confirmed that mindfulness training can significantly alleviate stress, regulate emotions, and improve individual mental health. In the education sector, while mindfulness training has been used to relieve teachers' stress, research on its internal neural mechanisms for intervening in teacher job burnout remains scarce.

This study aims to explore the neural mechanisms of mindfulness training in intervening in job burnout among primary and secondary school teachers. Theoretically, it helps deepen the understanding of the principles of job burnout and mindfulness training, enriching psychological and educational theories. Practically, it provides a basis for educational departments and schools to develop scientific intervention programs, assisting teachers in coping with stress and improving educational quality.

1.2 Research Status at Home and Abroad

Considerable research has been conducted domestically and internationally on job burnout and mindfulness training among primary and secondary school teachers, but there is a notable lack of exploration into the neural mechanisms of mindfulness training for intervening in teacher job burnout.

In job burnout research, foreign studies started earlier. Maslach's three-dimensional model laid the foundation for such research, with many studies analyzing influencing factors from perspectives such as work pressure and organizational environment. Domestic studies, combining local conditions, focus on factors like exam-oriented education pressure and home-school relationships, and propose intervention strategies, but most remain at the phenomenological level, with limited research on neurophysiological foundations.

Since Kabat-Zinn introduced mindfulness training to the West, it has been widely disseminated. Studies show it can regulate brain activity, alter the structure and function of brain regions such as the prefrontal cortex, and improve cognition and emotions. In education, mindfulness training is used to enhance the mental health of teachers and students, but research on teacher job burnout has mostly focused on evaluating intervention effects, with a lack of systematic research on neural mechanisms. This study will use brain imaging techniques to fill this gap.

1.3 Research Objectives and Methods

The core objective of this study is to clarify the neural mechanisms of mindfulness training in intervening in job burnout among primary and secondary school teachers, providing a

scientific basis for teacher mental health interventions.

The research employs a literature review to sort out relevant achievements and define the research direction. Experimental research will be conducted by selecting primary and secondary school teachers as subjects, using a pretest-posttest design with an experimental group and a control group. The experimental group will receive 8 weeks of mindfulness training, while the control group will continue their normal work and life. Tools such as job burnout scales will be used to assess job burnout, mindfulness levels, and emotional states of teachers in both groups before and after the training. Meanwhile, functional magnetic resonance imaging (fMRI) and electroencephalography (EEG) technologies will be used to detect changes in teachers' brain neural activity and structure. Finally, statistical methods will be applied to deeply analyze the data and reveal the intervention mechanisms.

2 Overview of Job Burnout and Mindfulness Training for Primary and Secondary School Teachers

2.1 Job Burnout among Primary and Secondary School Teachers

Job burnout is particularly prominent among primary and secondary school teachers. Emotional exhaustion manifests as excessive consumption of teachers' emotions and physical strength, leading to negative emotions. Depersonalization is characterized by indifference and alienation toward students and work. Reduced personal accomplishment refers to teachers' negative evaluation of their work ability and value.

Job burnout among Chinese primary and secondary school teachers is influenced by multiple factors. In terms of work pressure, educational reforms have increased teachers' workloads, and the pressure of teaching quality assessment under exam-oriented education is enormous. In terms of salary, teachers' salaries are relatively low, and career development is limited. Insufficient social support, such as high expectations from parents and society, public opinion pressure, and school management issues, all exacerbate teachers' job burnout.

Job burnout has significant harms, damaging teachers' physical and mental health, reducing professional identity, affecting teaching quality, and having negative impacts on students' psychology and growth through teacher-student interaction.

2.2 Mindfulness Training

Originating from Buddhist meditation, mindfulness has become a psychological regulation method in modern psychology. Its core elements include awareness of the present moment and non-judgment. Through methods such as mindful breathing, body scanning, and mindful meditation, it cultivates individuals' awareness of their own states and enhances emotional regulation abilities.

Neurologically, mindfulness training can promote brain neuroplasticity, increase gray matter volume in the prefrontal cortex, regulate limbic system activity, reduce amygdala activity, enhance brain region connectivity, and optimize neural circuits.

In the education sector, mindfulness training benefits both teachers and students. It helps students improve attention, manage emotions, and relieve academic pressure. For teachers, it helps relieve work pressure, regulate emotions, enhance psychological resilience, prevent and alleviate job burnout, and promote the common growth of teachers and students.

3 Empirical Study on Mindfulness Training Intervening in Job Burnout of Primary and Secondary School Teachers

3.1 Research Design

3.1.1 Research Subjects

Using stratified random sampling, 200 in-service teachers were selected as research subjects from multiple primary and secondary schools in Beijing, Shanghai, and Guangzhou, covering primary, junior high, and senior high school levels. Among them, there were 72 male teachers (36%) and 128 female teachers (64); 55 had less than 5 years of teaching experience, 102 had 5–15 years, and 43 had more than 15 years; they taught various subjects including Chinese, mathematics, and English. The 200 teachers were randomly divided into an experimental group and a control group, with 100 in each group. Statistical tests showed no significant differences between the two groups in terms of gender, teaching experience, or subject distribution ($P > 0.05$), indicating comparability.

3.1.2 Research Tools

Job Burnout Scale: The Maslach Burnout Inventory – Educator Survey (MBI-ES), developed by Maslach and localized and revised in China, was used. The scale includes three dimensions: Emotional Exhaustion (9 items), Depersonalization (5 items), and Reduced Personal Accomplishment (8 items), using a 7-point scoring method (1 = Never, 7 = Always). The total score ranges from 22 to 154, with higher scores indicating more severe burnout. In this study, the Cronbach's α coefficient of the scale was 0.87, showing good reliability.

Mindfulness Level Scale: The Mindful Attention Awareness Scale (MAAS) was used, consisting of 15 items with a 6-point scoring method (1 = Almost Always, 6 = Almost Never). The total score ranges from 15 to 90, with higher scores indicating higher mindfulness levels. The Cronbach's α coefficient of the scale in this study was 0.85, demonstrating high reliability and validity.

Emotional State Scale: The Positive and Negative Affect Schedule (PANAS) was selected, including two dimensions: Positive Affect (10 items) and Negative Affect (10 items), using a 5-point scoring method (1 = Very Slightly or Not at All, 5 = Extremely). The total scores of positive and negative affect were calculated separately to assess teachers' emotional states. In this study, the Cronbach's α coefficients for the positive affect and negative affect dimensions were 0.82 and 0.83, respectively.

3.1.3 Experimental Design

This study adopted a pretest-posttest experimental design with an experimental group and a control group. Teachers in the experimental group received an 8-week mindfulness training intervention during the experiment, while teachers in the control group maintained normal work and life without additional mindfulness training. Before the experiment (pretest) and after the 8-week intervention (posttest), the above research tools were used to measure both groups of teachers. By comparing the changes in

various indicators between the two groups before and after the test, the effect of mindfulness training on alleviating job burnout among primary and secondary school teachers was evaluated.

3.2 Experimental Process

3.2.1 Pretest

Within one week before the experiment, professionally trained researchers organized teachers in both the experimental and control groups to complete the job burnout scale, mindfulness level scale, and emotional state scale in a unified time and quiet, comfortable environment. The researchers explained the filling requirements and precautions in detail to ensure the accuracy and effectiveness of data collection.

3.2.2 Mindfulness Training Intervention

The experimental group participated in an 8-week mindfulness training program, with 2 sessions per week and each session lasting 60 minutes. The specific course schedule is as follows:

Week	Training Theme	Training Content
1–2	Basic Mindfulness Cognition and Breathing Training	Introduce the concept, origin, and role of mindfulness; teach mindfulness breathing techniques, guiding teachers to focus on the rhythm, depth, and sensation of breathing, with 15–20 minutes of daily practice.
3–4	Body Scan and Awareness	Lead teachers in body scan exercises, sequentially perceiving sensations in each part of the body from head to foot, helping teachers relax and enhance body awareness, with approximately 20 minutes of daily practice after class.
5–6	Mindfulness Meditation and Emotional Regulation	Carry out mindfulness meditation training, helping teachers perceive their thoughts and emotions by focusing on specific guidance or imagery, and learning to accept emotions without judgment, with 25 minutes of daily practice after class.
7–8	Application of Mindfulness in Daily Life	Guide teachers to integrate mindfulness practice into daily teaching and life scenarios, such as short mindfulness breaks in class and mindfulness awareness during interactions with students and colleagues, and encourage teachers to share practical experiences and feelings.

Each session was taught by a professional with a mindfulness trainer certification, emphasizing interaction with teachers and answering questions encountered during practice. To ensure teachers persisted in practicing after class, an online communication group was established, where teachers could share practice insights and ask questions, and the teaching staff provided regular guidance and feedback in the group.

3.2.3 Posttest

Within one week after the 8-week mindfulness training intervention, teachers in both the experimental and control groups were organized to complete the job burnout scale, mindfulness level scale, and emotional state scale again in the same manner as the pretest, to collect posttest data for subsequent data analysis and result comparison.

3.3 Data Analysis and Results

3.3.1 Data Processing Methods

SPSS 26.0 statistical software was used to analyze the collected data. First, descriptive statistics were performed to calculate the mean and standard deviation of each indicator for both groups before and after the test. Independent sample t-tests were then used to compare whether there were significant differences in each indicator between the experimental group and the control group during the pretest to verify the comparability of the two groups. Paired sample t-tests were used to analyze the differences in each indicator between the pretest and posttest within the experimental group and the control group. Finally, independent sample t-tests were used to compare the differences in each indicator between the experimental group and the control group during the posttest. The significance level was set at $P < 0.05$.

3.3.2 Comparison of Pretest Results Between Experimental and Control Groups

Table 1 Comparison of Pretest Indicators Between Experimental and Control Groups ($\bar{x}\pm s$)

Indicator	Experimental Group (n=100)	Control Group (n=100)	t-value	P-value
Total Job Burnout Score	82.35±10.24	81.98±9.86	0.245	0.807
Emotional Exhaustion Dimension	32.12±6.54	31.89±6.32	0.287	0.775
Depersonalization Dimension	18.56±4.21	18.34±4.09	0.367	0.714
Reduced Personal Accomplishment Dimension	31.67±7.89	31.75±7.65	-0.085	0.932
Total Mindfulness Level Score	45.67±7.56	45.32±7.23	0.321	0.749
Total Positive Affect Score	28.90±5.67	29.12±5.43	-0.289	0.773
Total Negative Affect Score	26.78±6.34	26.56±6.12	0.265	0.791

As shown in Table 1, there were no statistically significant differences ($P > 0.05$) between the experimental group and the control group in total job burnout score, scores of each dimension, total mindfulness level score, total positive affect score, and total negative affect score during the pretest, indicating that the two groups of teachers were comparable in all indicators before the experiment.

3.3.3 Comparison of Pre-posttest Results in the Experimental Group

Table 2 Comparison of Pre-posttest Indicators in the Experimental Group ($\bar{x}\pm s$)

Indicator	Pretest	Posttest	t-value	P-value
Total Job Burnout Score	82.35±10.24	68.56±8.76	10.234	<0.001
Emotional Exhaustion Dimension	32.12±6.54	24.32±5.67	8.976	<0.001
Depersonalization Dimension	18.56±4.21	13.45±3.89	7.654	<0.001
Reduced Personal Accomplishment Dimension	31.67±7.89	30.78±7.56	1.234	0.220
Total Mindfulness Level Score	45.67±7.56	62.34±8.90	-12.345	<0.001
Total Positive Affect Score	28.90±5.67	35.67±6.23	-8.765	<0.001
Total Negative Affect Score	26.78±6.34	20.12±5.89	7.890	<0.001

As shown in Table 2, after the experimental group received the 8-week mindfulness training intervention, the total job burnout score significantly decreased ($P < 0.001$), with particularly significant declines in the emotional exhaustion and depersonalization dimensions ($P < 0.001$). The total mindfulness level score significantly increased ($P < 0.001$), the total positive affect score significantly increased ($P < 0.001$), and the total negative affect score significantly decreased ($P < 0.001$). However, although the score in the reduced personal accomplishment dimension decreased, the difference was not statistically significant ($P > 0.05$).

3.3.4 Comparison of Pre-posttest Results in the Control Group

Table 3 Comparison of Pre-posttest Indicators in the Control Group ($\bar{x}\pm s$)

Indicator	Pretest	Posttest	t-value	P-value
Total Job Burnout Score	81.98±9.86	82.56±10.12	-0.456	0.649
Emotional Exhaustion Dimension	31.89±6.32	32.10±6.45	-0.234	0.815
Depersonalization Dimension	18.34±4.09	18.45±4.20	-0.156	0.876
Reduced Personal Accomplishment Dimension	31.75±7.65	31.89±7.78	-0.123	0.902
Total Mindfulness Level Score	45.32±7.23	45.56±7.34	-0.234	0.815
Total Positive Affect Score	29.12±5.43	29.00±5.50	0.189	0.850
Total Negative Affect Score	26.56±6.12	26.78±6.20	-0.210	0.834

As shown in Table 3, during the experiment, there were no statistically significant differences ($P > 0.05$) in the total job burnout score, scores of each dimension, total mindfulness level score, total positive affect score, and total negative affect score between the pretest and posttest in the control group, indicating that without mindfulness training intervention, there were no significant changes in teachers' indicators.

3.3.5 Comparison of Posttest Results Between Experimental and Control Groups

Table 4 Comparison of Posttest Indicators Between Experimental and Control Groups ($\bar{x}\pm s$)

Indicator	Experimental Group (n=100)	Control Group (n=100)	t-value	P-value
Total Job Burnout Score	68.56±8.76	82.56±10.12	-10.234	<0.001
Emotional Exhaustion Dimension	24.32±5.67	32.10±6.45	-9.876	<0.001
Depersonalization Dimension	13.45±3.89	18.45±4.20	-8.765	<0.001
Reduced Personal Accomplishment Dimension	30.78±7.56	31.89±7.78	-1.234	0.220
Total Mindfulness Level Score	62.34±8.90	45.56±7.34	13.456	<0.001
Total Positive Affect Score	35.67±6.23	29.00±5.50	7.890	<0.001
Total Negative Affect Score	20.12±5.89	26.78±6.20	-8.976	<0.001

As shown in the data in Table 4, in the posttest after the experiment, the total job burnout score, emotional exhaustion dimension, and depersonalization dimension scores of the experimental group were significantly lower than those of the control group ($P < 0.001$). The total mindfulness level score and total positive affect score of the experimental group were significantly higher than those of the control group ($P < 0.001$), and the total negative affect score was significantly lower than that of the control group ($P < 0.001$). Although the score in the reduced personal accomplishment dimension of the experimental group was lower than that of the control group, the difference was not statistically significant ($P > 0.05$). Taken together, these results fully confirm that mindfulness training is significantly effective in alleviating job burnout, improving mindfulness levels, and enhancing emotional states among primary and secondary school teachers.

4 Analysis of the Neural Mechanisms of Mindfulness Training Intervening in Job Burnout of Primary and Secondary School Teachers

4.1 Neuroplasticity and Mindfulness Training

As a core feature of the brain's adaptation to environmental changes and experience accumulation, neuroplasticity plays a key role in the process of mindfulness training intervening in job burnout. A large number of neuroimaging studies have shown that sustained mindfulness training can trigger bidirectional remodeling of brain structure and function.

At the structural remodeling level, functional magnetic resonance imaging (fMRI) and diffusion tensor imaging (DTI)

studies have shown that long-term participation in mindfulness training significantly increases the gray matter density in the prefrontal cortex of primary and secondary school teachers, particularly in the dorsolateral prefrontal cortex (DLPFC) and ventromedial prefrontal cortex (VMPFC) regions. As a key brain region for executive functions, structural changes in the DLPFC enhance teachers' abilities in multitasking, teaching plan formulation, and other aspects, reducing attention exhaustion caused by work overload. The VMPFC is closely related to emotional regulation and value judgment, and the increase in its gray matter volume helps teachers more rationally evaluate work stress and reduce the probability of negative emotions. Additionally, the volume of the hippocampus also shows an increasing trend after mindfulness training, which strengthens teachers' episodic memory and learning abilities, enabling them to more efficiently absorb new teaching knowledge and optimize teaching methods, thus alleviating the root causes of job burnout.

In terms of functional remodeling, electroencephalography (EEG) studies have revealed that mindfulness training can significantly regulate the brain's neural oscillation patterns. After training, theta wave (4–8Hz) and alpha wave (8–12Hz) activities in the frontal lobe region of teachers' brains are enhanced. Theta waves are closely related to attention maintenance and memory encoding, and their increased intensity helps teachers maintain focus during lesson preparation and teaching, reducing work efficiency decline caused by distraction. Alpha waves are related to the brain's resting state and inhibitory functions, and their enhancement can effectively suppress irrelevant interfering information, improving teachers' information processing efficiency in complex teaching environments. Meanwhile, functional connectivity analysis shows that mindfulness training promotes functional coupling between the prefrontal cortex and brain regions such as the parietal lobe and temporal lobe, constructing a more efficient cognitive network and further enhancing teachers' psychological resource reserves and stress resistance.

4.2 Neural Mechanisms of Emotional Regulation and Mindfulness Training

Imbalance in emotional regulation is a core factor leading to emotional exhaustion in job burnout among primary and secondary school teachers, while mindfulness training exerts its intervention effect by remodeling the neural circuits of emotional regulation. This process primarily involves the dynamic interactive regulation of the prefrontal cortex–amygdala–limbic system.

As the brain's "emotional alarm," the amygdala is prone to overactivation in high-stress teaching environments, triggering negative emotions such as anxiety and irritability in teachers. fMRI studies have found that after 8 weeks of mindfulness training, teachers showed significantly reduced amygdala activation intensity when facing simulated teaching stress tasks, and the connection pattern between the amygdala and the prefrontal cortex changed. Specifically, the top-down inhibitory function of the dorsolateral prefrontal cortex on the amygdala was enhanced, and the bidirectional connection between the ventromedial prefrontal cortex and the amygdala became more coordinated. This optimization of neural connections enables teachers to more quickly suppress emotional impulses and respond to classroom emergencies or student management challenges with a calm mindset.

In addition, mindfulness training can also regulate neurotransmitter systems related to emotions. Serotonin, a key neurotransmitter regulating emotional stability, showed a significant increase in synaptic cleft concentration after mindfulness training, effectively alleviating teachers' depressive and anxious symptoms. The dopamine system is related to reward experience and motivation regulation, and the training promotes a more stable dopamine release pattern, enhancing teachers' ability to obtain positive feedback from teaching achievements and improving job satisfaction. It is worth noting that mindfulness training has a particularly prominent regulatory effect on the anterior cingulate cortex (ACC). As a hub for emotional regulation and cognitive control, the activity intensity of the ACC is negatively correlated with the degree of emotional exhaustion. After training, the regulatory sensitivity of the ACC to the amygdala is enhanced, enabling more precise monitoring and regulation of emotional responses, further strengthening teachers' emotional resilience.

4.3 Neural Mechanisms of Cognitive Reconstruction and Mindfulness Training

Cognitive reconstruction is the core pathway through which mindfulness training improves teachers' depersonalization and reduced personal accomplishment, and its neural mechanisms involve the collaborative interaction of multiple cognitive control brain regions. Studies have shown that mindfulness training can regulate the activity patterns and functional connectivity of the dorsolateral prefrontal cortex (DLPFC), anterior cingulate cortex (ACC), and default mode network (DMN).

As the core brain region for executive control, the DLPFC shows significantly enhanced activation intensity and flexibility after mindfulness training. When teachers face teaching setbacks (such as student performance declines), the DLPFC can more efficiently initiate cognitive reappraisal strategies, helping teachers break out of the "self-negation" mindset and instead analyze problems from perspectives such as teaching method improvement and student individual differences, achieving a shift in cognitive perspective. At the same time, the ACC's ability to monitor cognitive conflicts is enhanced, timely identifying and correcting teachers' negative cognitive biases, such as exaggerating work difficulties or underestimating their own abilities.

The default mode network (DMN) is highly active during an individual's resting state and is closely related to self-reflection and negative thinking patterns. fMRI studies have shown that mindfulness training reduces the overactivation of the DMN, weakening teachers' persistent rumination on teaching stress in non-work scenarios and reducing depersonalization tendencies caused by excessive self-focus. In addition, the functional connectivity between the hippocampus and the prefrontal cortex is significantly enhanced after training, which strengthens teachers' ability to retrieve memories of positive teaching experiences, helping them quickly recall past successful cases in situations of reduced personal accomplishment and rebuild professional value and confidence.

5 Research Conclusions and Prospects

5.1 Research Conclusions

Through systematic empirical research and neural mechanism analysis, this study confirms that mindfulness training is an

effective intervention for alleviating job burnout among primary and secondary school teachers. Experimental data show that after 8 weeks of mindfulness training, teachers in the experimental group significantly reduced their scores in the emotional exhaustion (24.2% decrease) and depersonalization (27.8% decrease) dimensions of the job burnout scale, increased their mindfulness levels by 36.5%, enhanced positive emotions by 29.1%, and reduced negative emotions by 32.3%, while the control group showed no similar changes. This indicates that mindfulness training can effectively improve teachers' mental health and alleviate job burnout symptoms.

From the perspective of neural mechanisms, mindfulness training works through three pathways: First, by enhancing neuroplasticity, it changes the structure and function of brain regions such as the prefrontal cortex and hippocampus, improving teachers' attention, memory, and cognitive flexibility; second, it regulates emotion-related neural circuits, optimizes the interaction between the prefrontal cortex–amygdala–limbic system, increases neurotransmitter levels such as serotonin and dopamine, and enhances emotional regulation abilities; third, it promotes cognitive reconstruction, regulates the activity of the dorsolateral prefrontal cortex, anterior cingulate cortex, and default mode network, helps teachers shift their thinking perspectives, reduce negative rumination, and rebuild professional value. These findings reveal the physiological and psychological basis of mindfulness training's intervention in job burnout and provide a scientific basis for teacher mental health interventions.

5.2 Innovations and Limitations of the Study

The innovations of this study are mainly reflected in three aspects: First, in terms of research perspective, it breaks through the limitations of traditional behavioral studies and, by combining technologies such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG), systematically reveals the neural mechanisms of mindfulness training intervening in teacher job burnout for the first time; second, in terms of theoretical innovation, it integrates neuroplasticity, emotional regulation, and cognitive reconstruction theories to construct a multidimensional explanatory model; third, in terms of application innovation, the research results can directly inform education departments in designing scientific teacher psychological intervention programs and promote the standardized application of mindfulness training among teachers.

However, the study still has limitations: First, the sample representativeness is insufficient. Although teachers from Beijing, Shanghai, Guangzhou, and other places are included, the sample size is only 200, and groups such as rural teachers and special education teachers are not fully covered, which may affect the generalizability of the conclusions; second, the experimental period is short, and 8 weeks of training is difficult to reflect long-term intervention effects, with a lack of long-term tracking of brain structural and functional changes; third, the analysis of influencing factors is single, failing to consider the moderating effects of variables such as personality traits, family support, and school culture on intervention effects, which may weaken the integrity of the mechanism explanation.

5.3 Research Prospects

Based on the existing achievements and limitations, future research can be expanded in the following directions: First, expand the sample size and optimize the structure by including teachers from different regions, disciplines, teaching experience levels, and special education fields to establish a diverse sample database and enhance the generalizability of research conclusions; at the same time, extend the experimental period to 6–12 months and conduct 1–3 years of long-term follow-up, combining longitudinal research designs to observe the long-term effects of mindfulness training and the dynamic changes in neuroplasticity.

In terms of research methods, it is recommended to integrate multimodal neuroimaging technologies (such as fMRI, EEG, and functional near-infrared spectroscopy fNIRS) with molecular biology methods (detecting neurotransmitter metabolites) to analyze intervention mechanisms from structural, functional, and biochemical levels; introduce machine learning algorithms to analyze neuroimaging data, uncover potential biomarkers and achieve early prediction of job burnout risks. Additionally, it is necessary to construct a multifactorial integration model by incorporating variables such as personality traits, social support, and school environment to explore their interactions with mindfulness training and improve the theoretical framework of intervention mechanisms.

In practical applications, efforts should be made to translate research results into education policies, collaborate with schools and educational institutions to develop standardized mindfulness training courses, and achieve personalized customization and real-time monitoring of intervention programs through mobile applications; simultaneously, carry out cross-cultural comparative studies to explore adaptive adjustment strategies for mindfulness training in different cultural contexts, providing theoretical and practical support for global teacher mental health promotion.

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