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Contents

From Irrationality to Rationality: The Restatement of Memory in "Once Upon a Time: A Floating Opera"

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Abstract: Once Upon a Time: A Floating Opera is a late autobiographical work written by John Barth, a leading figure in American postmodernist literature. It extends Barth's signature technique of "restatement", forming a mnemonic relationship with his earlier works, The Floating Opera and The End of the Road. The love memories in Once Upon a Time are not mere repetitions but exhibit the characteristics of functional memory in Aleida Assmann's cultural memory theory, emphasizing the interplay between passion and rationality while dissecting the ethical implications of self-consciousness. Thus, the novel elucidates the unique ethical concerns of postmodernist literature.

Keywords: Once Upon a Time; A Floating Opera; John Barth; functional memory; irrationality; rationality

1. Introduction

Once Upon a Time: A Floating Opera (1994) is Barth's autobiographical novel, in which he assumes the persona of the protagonist, "Oatmeal," endowing him with the identity of a writer. Through Oatmeal's reflections on love, Barth explores the process of literary creation while revealing his own self-awareness in writing. The novel, structured around a modern love story, restates the romantic narratives from The Floating Opera and The End of the Road, skillfully illustrating the relationship between remembering and being remembered. This relationship is not one of simple repetition but is marked by transformation and reconstruction. As Assmann notes, "[r]emembering is basically a reconstructive process; it always starts in the present, and so inevitably at the time when memory is recalled, there will be shifting, distortion, revaluation, reshaping" (Assmann, 2011: 19). In Once Upon a Time, the revalued love memory manifests as an evolution in the nature of love. With temporal distance, memory "takes on a different quality" (Assmann, 2011: 4). In Barth's early works, love was merely a thematic representation of nihilism, but in Once Upon a Time, it shifts from the real world to the realm of creative thought, "artistic technique is as important as the technique of love" (Barth, 1994: 56). Through Oatmeal's love story, Barth restates the irrational love in The Floating Opera and the detached love in The End of the Road, infusing the memory of love with both passionate emotion and rational responsibility, thereby exploring the dialectic between passion and rationality in love.

2. The Revaluation of Love Memory

The love memory in Barth's novel refers to Oatmeal's narration and recollection of his romantic experiences in Once Upon a Time. These stories blend personal experiences with the classic love motifs from Barth's earlier works, such as the irrational love in The Floating Opera, where the protagonist Andrews prioritizes desire over emotion, treating love as a sacrifice for self-awareness. In contrast, Oatmeal's love in Once Upon a Time is grounded in genuine emotion and structured by sober self-awareness, forming an orderly matrix of affection.

The defining trait of Andrews' love in The Floating Opera is irrationality. Through this anti-hero, Barth deconstructs traditional romantic narratives: Andrews is ensnared in the animalistic whirlpool of lust, reducing relationships to a dramatized display of biological instinct. His emotional patterns are distinctly deconstructive manipulating a high school classmate's feelings, engaging in racially and sexually oppressive behavior toward a Black woman, and ultimately crossing ethical boundaries by having an affair with a friend's wife. These actions systematically dismantle the sanctity of love. In Once Upon a Time, however, Oatmeal's love narrative introduces a unique philosophical dimension. Unlike the one-dimensional glorification of passion in traditional romanticism, Oatmeal embodies the existentialist proposition that

"even the strongest emotion can be rational" (Barth, 1994: 275), deconstructing the primal myth of irrational desire and reconstructing the ethics of love. His philosophy of love is built on a dual ontology: while affirming the indissolubility of passion as an emotional substrate, it insists that such passion must be dialectically unified with "authentic love" (Barth, 1994: 279) under the lens of intersubjectivity and self-reflexive cognition. This cognitive paradigm, which subjects emotional experience to rational scrutiny, stands in stark opposition to Andrews' biologically driven desire, reflecting profound philosophical introspection into human nature within a postmodern context.

In Oatmeal's world, the essence of love lies in the spiritual resonance forged through deep emotional and cognitive alignment, transcending superficial attraction to form the core of intimacy. He positions himself as a "Dante character" (Barth, 1994: 384), alluding to the Italian poet's sublime love for Beatrice to signify a pure, soul-deep affection that rejects the "existential statement" of primal desire in favor of an "authentic kind" (Barth, 1994: 279) of spiritual harmony. Moreover, self-awareness is a crucial factor in Oatmeal's love, guided by the "Reality Principle" (Barth, 1994: 1), which serves as a moral compass. In constructing his relationships, self-awareness acts like a navigator's sextant, determining the coordinates of love's trajectory. Barth's metaphorical voyage on the cutter "US" reveals: "the first and final narrative question is not 'what happened?' but 'who am I?'" (Barth, 1994: 319). This cognitive framework transforms self-definition into a mechanism for ethical calibration through continuous introspection can one establish a stable value system, pierce the fog of misperception in intimacy, and refine moral judgment in practice. Such lucid self-mapping not only provides a baseline for choosing partners but also forms a cognitive immune system against emotional chaos, elevating relationships from randomness to a life practice imbued with ethical consciousness and personal integrity.

Oatmeal's view of love employs the humble imagery of oats to construct a profound emotional philosophy. At its core, passion is not fleeting excitement but a slow, natural release of fragrance, like oats ground between millstones—a radiant spark of soulful connection. This passion is rooted in the soil of sober self-awareness, akin to oats' precise response to sunlight and rain. Through ongoing introspection, Oatmeal builds a multidimensional mirror reflecting his values, emotional needs, and personality traits, where emotional impulses refract into spectra of rationality through the prism of self-knowledge, while rational frameworks retain flexibility under the infusion of emotion.

3. Restating Rational Responsibility

Beyond passionate rationality, Oatmeal's love also redefines rational responsibility. His narrative transcends instrumental rationality, demonstrating through reconstructed emotional experience that "rationality can be impassioned" (Barth, 1994: 275), thereby subversively restructuring the detached love in The End of the Road. Responsibility no longer implies emotional withdrawal but requires encompassing both ethical duty to the other and emotional engagement.

In The End of the Road, the protagonist Joe exhibits chilling intellectual rigidity. He forces emotions into logical equations, demanding his wife Rennie to worship his "absolutes" (Barth, 1988: 361) with the blade of analytic philosophy, reducing marriage to a sterile syllogism. When Rennie's infidelity surfaces, Joe coldly assesses its validity like a lab observer. In his schema, loyalty is a mere premise, and emotional tremors are cognitive errors to be corrected. This extreme rationalism, divorcing humanity from lived experience, creates a moral void more destructive than betrayal—as the narrator in Once Upon a Time observes, "the opposite of reason isn't emotion, man; it's unreason. And the opposite of emotion isn't reason; it's frigidity" (Barth, 1994: 275). Stripped of empathy, reason leaves not clarity but absolute zero of feeling. Joe's suspension of ethical responsibility makes him a walking paradox: deconstructing marital obligations with logic while demanding adherence to metaphysical ideals. This rupture between intellect and morality epitomizes modernity's pathology.

In contrast, Oatmeal's love centers on fulfilling rational responsibility in relationships—establishing ethical accountability to the other while sustaining emotional investment. This paradigm structurally opposes postmodern detached love, differentiating itself through the presence or absence of responsible subjectivity. Oatmeal insists on absolute responsibility to the other, grounding it in real-world relevance. His practical commitments reflect serious engagement with the other, distinct from Joe's mechanical rationality fixated on absolute values. This underscores that love is incompatible with imposing one's own will upon others, and the responsibility towards the other should

be rooted in real life.

This thus determines that the second crucial element of rational responsibility is active engagement in the emotional dimension, maintaining positive emotional participation and sustained attention. Oatmeal argues that only by focusing on those "lofty abstractions: Truth, Goodness, Beauty" (Barth, 1994: 371) can the effective expression of love be achieved. The love memory between Oatmeal and Miss R, constructed on the triple dimensions of truth, goodness, and beauty, reveals three core dimensions inherent in the essence of love: emotional loyalty, relational tolerance, and temporal endurance. It can be said that Oatmeal's emotional practice forms a unique dialectic of responsibility: while preserving the tension of intersubjectivity, his emotional investment is consistently accompanied by a conscious bearing of rational responsibility. This synthesis of emotion and responsibility deconstructs the traditional binary opposition between rationality and emotion, ultimately achieving a critical transcendence of the nihilistic paradigm of love presented in The End of the Road.

4. The Ethical Implications of Self-Consciousness in Literary Creation

In Once Upon a Time, Oatmeal's rational-ethical self-awareness manifests primarily in his sense of responsibility. When consciousness confirms its existence through mnemonic reflection, "literature is in essence, an art of ethics" (Nie, 2021: 190). Oatmeal's rational self-awareness and ethical introspection amplify Barth's postmodern emphasis on responding to the other's ethical call.

Oatmeal's real-world engagement demonstrates absolute responsibility to the other, reflecting Barth's insistence on life as literature's foundation. Compared to Joe's detached love, Oatmeal's choices highlight proactive intervention guided by ethics of responsibility—transforming intimacy into daily practice through domestic commitments. Barth uses Oatmeal's contractual fidelity to argue that artists must strengthen life consciousness in writing. Barth posits that texts emerge from the fusion of life and writing, advocating dual narrative dimensions: depicting "how our real lives are really lived, as well as our life stories" (Barth, 1994: 20). This demands both faithful documentation of experience and meta-reflection on narration itself, integrating "the procedural encoding of explicit memory with the automatic retrieval of implicit memory into narrative construction" (Erll, 2022: 1-2). For Barth, life is the primordial field supplying textual raw material; writing decodes and recodes lived experience. Language abstracts reality into symbolic order, revealing the translation from life-signs to text-signs—a dynamic hermeneutic cycle beyond mere mirroring or transplantation. When words disrupt linear signifier-signified relations, literary creation achieves transdimensional dialogue between experience and semiotic world. The intertextual tension between life and text ultimately generates transcendental aesthetic meaning at cognition's limits.

Barth's framework reaffirms "[t]he independent life of objects" (Barth, 1994: 346), establishing two theoretical axes: ontologically, texts must root in lived experience; methodologically, textual self-disclosure fuses life and writing. This Zen-like selflessness requires writers to transcend technical rationality, relinquishing authorial hegemony to grant texts autonomy. Barth's ideal rational writer reveres narrative ontology—replacing realistic simulation with precise strategies that let texts reveal themselves, bridging art and reality via bidirectional aesthetic channels. When texts escape authorial presuppositions to speak independently, their referential systems unveil life's texture, empowering literature to intervene in reality and uncover truth. Thus, Barth crafts not just a poetics of text-production but a philosophy of creative redemption.

Secondly, Oatmeal's active emotional projection in love metaphorically mirrors Barth's affective codes in writing. In Once Upon a Time, Oatmeal asserts that rationality brimming with passion requires emotional investment, extending love's truth-goodness-beauty triad to art's canon—from Sophocles to Camus. Barth's subtext is that writers must learn from literary masters to inject authentic emotion into texts, constructing positive affect for sentimental impact, embodying rational responsibility rather than detached reason.

Thus, Barth's postmodern affective poetics centers on textual self-generation for dynamic emotional construction. This operates through dual paradigms: "file footage" (Barth, 1994: 361) building collective ethics, and individual life writing anchoring personal existence. In the creative practice of Once Upon a Time, Barth's systematically deconstructs the paradigm of traditional emotional writing. He explicitly points out that emotional construction in the postmodern context should not indulge in the mechanical accumulation of details but should instead rely on narrative units with archival qualities. This creative concept exemplifies the postmodern writing

characteristic that "memory constructs texts by structuring narration" (Wójcicka, 2020: 56). This "Newspaper-Real" (Barth, 1994: 357) writing strategy employs a de-dramatized, objective presentation to establish a shared ethical category based on authenticity within the textual space. This generative approach abandons preset ethical value systems, opting instead for a backgrounded, fragmented combination of archival lenses to stimulate readers to autonomously reconstruct emotional logic on a cognitive level.

In terms of the mechanism of emotional generation, Barth particularly emphasizes the dialectical relationship between file footage and personal life. File footage, as the material carrier of collective memory, forms the foundational framework for ethical consensus through depersonalized historical fragments, while personal life writing infuses tangible lived experiences through micro-narratives. The interaction between the two within the text creates a unique structure of tension: the former constructs an ethical domain with universal significance, while the latter provides an individualized frame of reference for existence. The emotional resonance ultimately achieved through this dual writing strategy is neither the tear-jerking effect of traditional tragedy nor the ironic detachment common in postmodern works, but rather an introspective resonance generated through cognitive reconstruction—readers, grounded in the authenticity of archival footage and refracted through the mirror of personal life, arrive at a multidimensional understanding and profound reflection on the human condition.

It is noteworthy that Bath's theory of emotional generation consistently maintains a sharp responsiveness to the postmodern context. The use of archival footage serves not only as a literary translation of media reality in the information age but also as an active exploration of reconstructing collective memory in the wake of the dissolution of grand narratives. Meanwhile, the heightened focus on personal life narratives reflects a creative consciousness aimed at redefining the meaning of individual existence amidst the postmodern crisis of fragmented subjectivity. This dual-dimensional emotional construction ultimately achieves an organic fusion of historical truth and personal experience at the textual level, forging a new paradigm of emotional resonance with cognitive depth.

In short, John Barth's postmodern literary thought is centered on a rationally self-aware writing ethic, constructing a cognitive topology of the text through dual dimensions: on one hand, it employs textual self-revelation as a device for unveiling, performing the intertextual tensions of the lifeworld within the fabric of discourse, thereby transforming the substrate of experience into narrative codes imbued with ontological weight. On the other hand, it utilizes textual self-generation to dynamically weave an affective topology, facilitating the self-organizing evolution of semiotic systems. While deconstructing grand narratives, it simultaneously achieves the embodied reconstruction of micro-poetics, ultimately realizing the symbiotic augmentation of cognitive intensity and humanistic warmth within the linguistic crystal.

5. Conclusion

John Barth's fictional world is "[a] world in which everything is double, in which the same thing always happens twice" (Martin, 2008: 117). *Once Upon a Time*, as a functional memory reconstruction text within Barth's literary practice, derives its core value from achieving an aesthetic shift from irrational narration to rational speculation. Through a critical reconstruction of the irrational elements in his earlier works and a rational re-examination of memory via metafictional strategies, the author's self-referential creative practice not only accomplishes a cognitive upgrade of literary memory but also, through textual self-disclosure and self-generation, ultimately points toward his postmodernist literary vision. By revaluing love memory and reasserting rational responsibility, Barth clarifies the interplay of passion and reason within his ethical consciousness, thereby reflecting his postmodern literary philosophy and establishing an effective connection between the textual world and the realistic world. Thus, it is not that "Barth progressively loses interest in the tensions between the world and the stories that we concoct about it" (Edmundson, 1991: 45), but rather that he demonstrates his humanistic concern in an intelligibly postmodern manner, revealing his ultimate concern for the fate of human existence.

For Barth, a writer's ethical engagement must not be confined to a binary framework of moral judgment. Consequently, his literary practice consciously avoids the struggle for discursive authority in ethical interpretation, opting instead to engage with the

ontological examination of ethical events from a detached perspective. His aim is to shift toward a rigorous inquiry into socio-cultural morality and the individual practice of a proactive life philosophy through textual self-disclosure and self-generation. From this perspective, the existential wisdom revealed in Barth's literary schema is characterized by its transcendence of rigid ethical paradigms in favor of constructing a dynamic subjective response mechanism. Mature existential wisdom does not manifest as a utopian pursuit of eternal moral order but rather as the cognitive subject's creative response to socio-cultural transformations and value reconstruction. This is achieved through the dialectical unity of intellectual capability and ethical awareness, all while acknowledging the inherent complexity of the world.

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Analysis of the Moderating Effect of Sport Confidence on the Relationship Between Achievement Goal Orientation and Competitive State Anxiety in Korean Judo Athletes

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Abstract: The purpose of this study is to investigate the impact of achievement goal orientation on competitive state in Korean judo athletes, and to examine the moderating effect of sport confidence on the relationship between these two variables. A survey was conducted with male and female athletes aged 17 and older, registered with the Korea Judo Association, including high school, national team, and professional team members. A total of 301 responses were analyzed using SPSS 25.0, and the moderating effect was examined using PROCESS Macro for SPSS. First, among the sub-factors of achievement goal orientation, ego orientation was found to have a significant effect on the cognitive state and somatic state, which are sub-factors of competitive state anxiety, whereas task orientation did not have a significant effect on either cognitive or somatic states. Second, sport confid7ence was found to have a moderating effect on the relationship between achievement goal orientation and competitive state anxiety. Korean judo coaches should first assess the level of achievement goal orientation of their athletes and provide appropriate guidance and strategies based on this assessment. While the technical aspects of judo are important, it is crucial to focus on fostering an optimal level of confidence, rather than excessively high confidence, in order to reduce anxiety during competitions.

Keyword: Korean Judo Athletes, Achievement Goal Orientation, Competitive State Anxiety, Moderating Effect of Sport Confidence.

I.Introduction

1. Necessity and Purpose of the Research

Korean judo has achieved remarkable success in world championships and the Olympic Games, producing many world-class judo athletes. This success can be attributed to the strategic planning and adaptation based on the experiences of many coaches and their analysis of opponents (Kim, 2015). In particular, it is evident that both physical and mental factors have a significant impact on the outcome of the match (Choi, 2000). These factors are directly influenced by elements identified in the field of sports psychology, such as individual psychological factors, including achievement motivation, personality, and competitive anxiety, as well as social factors surrounding the individual, such as group cohesion, leadership, and social facilitation (Cox, 1985). Among these, the psychological factor of achievement goal orientation has emerged as a key concern in athletic performance, as it aids athletes in setting effective and efficient goals (Cho, Park, Lee, & Jeong, 2013).

Achievement Goal Orientation refers to the conceptualization of an individual's goal orientation, which is based on the fundamental achievement motivation in sports contexts. The outcomes of success and failure for athletes can be attributed to the psychological factors of individual achievement (Kim, 2005). Moreover, achievement goal orientation differs from self-confidence and significantly influences athletic performance. According to prior research, Hwang (2009) found that the achievement goal orientation of dance-majoring university students had a significant effect on their satisfaction with physical expression. Similarly, Kim and Kim (2010) showed

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that Taekwondo athletes' achievement goal orientation had a highly positive impact on anxiety in sports situations. Cho (2006) indicated that the higher the ego-orientation of figure skaters, the higher their competitive state anxiety. Kim (2011) also reported that ego-orientation in shooters significantly affected their competitive state anxiety. As demonstrated by these previous studies, a stronger achievement goal orientation aimed at overcoming opponents can lead to reduced anxiety, thereby positively influencing athletic performance outcomes. Thus, there is a strong correlation between achievement goal orientation and competitive state anxiety.

Competitive state anxiety refers to the temporary feelings of worry and tension experienced by athletes in specific competitive situations, representing their anxious state while in competition. This emotional state is related to the temporary activation of the autonomic nervous system in response to specific competitive situations and is subjectively and consciously perceived as cognitive anxiety. It is characterized by fear caused by worry, physiological reactions, and physical anxiety, resulting in a continuously fluctuating emotional state. Lander (1980) identified competitive state anxiety as a significant factor influencing athletes' performance during competitions. Loehr (1982) stated that an ideal psychological state is a phenomenon that universally affects individuals, regardless of the type of sport or the athletes' skill levels. Roberts and Treasure (1992) argued that athletes with high achievement goal orientation do not experience high levels of state anxiety as they evaluate their success based on their own criteria. Conversely, athletes with high achievement goal orientation may experience increased competitive state anxiety when they perceive their abilities to be inferior to those of other athletes. Shim (2006) explained that competitive state anxiety emerges as a temporary emotional state accompanied by arousal, influenced by both internal factors subjectively and consciously perceived in competitive situations and external stimuli. It primarily originates from external aspects of the competition and affects athletic performance. Lee (2019) claimed that during competition, if the point gap between an athlete and their opponent becomes significant, the athlete's concentration and confidence in their performance decrease. Conversely, when the point gap is minimal, anxiety levels tend to increase. Therefore, it is important for coaches to recognize that psychological factors are as crucial as technical aspects when guiding athletes. Furthermore, it has been reported that achievement goal orientation is closely related to sports confidence (Lee, 2022; Kim, 2019; Kim, 2019; Shin & Heo, 2018). Shim (2006) found that task-oriented orientation in judo athletes significantly affects state sports confidence and specific sports confidence. Kim (2010) demonstrated that ego-oriented achievement goal orientation in Taekwondo athletes positively influences sports confidence. Lee and Oh (2012) found that achievement goal orientation in bowling athletes positively impacts social support confidence. Kim (2012) also identified that task orientation in golf athletes has a significant effect on sports confidence. Kim (2013) demonstrated that the achievement goal orientation of boxing athletes positively affects coaching leadership, ability demonstration, and social support. As these previous studies indicate, there is a strong correlation between achievement goal orientation and confidence, and it can be concluded that achievement goal orientation has a significant impact on sports confidence.

Based on the previous studies reviewed so far, it can be concluded that the influence of achievement goal orientation on various psychological factors differs depending on the level of sports confidence. This suggests the potential moderating effect of sports confidence in the relationships between these variables. A moderating effect occurs when a third variable intervenes in the relationship between the independent and dependent variables, altering the strength of the effect of the independent variable on the dependent variable. This third variable is referred to as a moderator (Kim, 2020). Therefore, setting sports confidence as a moderating variable and verifying its effect in this study can be considered a meaningful research endeavor.

2. Research Questions

The purpose of this study is to examine the effect of achievement goal orientation on competitive state anxiety among Korean judo athletes, and to verify how sports confidence moderates the relationship between these two variables. The research questions to verify this purpose are as follows:First, what is the effect of achievement goal orientation on competitive state anxiety among Korean judo athletes?Second, how does sports confidence moderate the effect of achievement goal orientation on competitive state anxiety among Korean judo athletes?

II.Research Method

1. Participants

This study selected male and female athletes aged 17 and older, registered with the Korea Judo Association, including high school, university, national team, and professional team athletes, using a convenience sampling method, a type of non-probability sampling. A total of 350 questionnaires were distributed, and after excluding 49 questionnaires deemed unreliable or insufficiently answered, 301 questionnaires were used for the final analysis. The demographic characteristics of the participants are shown in Table 1.

Table 1. Demographic Characteristics

Variable	Item	Frequency	%
Gender	Male	205	68.1
	Female	96	31.9
Age	17 to 19 years old	96	31.9
	19 and older	205	68.1
Career	Up to 5 years	23	7.6
	Between 5 and 10 years	223	74.1
	over 10 years	55	18.3
Exercise Frequency	Less than 3 occurrences	7	2.3
	between 4 and 5 times or fewer	44	14.6
	more than 5 times	250	83.1
total		301	100%

2. Research Instruments

To measure the achievement goal orientation of Korean judo athletes, this study utilized a questionnaire adapted and refined based on the surveys used in the studies by Kwon (2008) and Wang (2012). The questionnaire for competitive state anxiety was adapted and refined from the surveys used by Kang (2014) and Kim (2011) to fit the context of this study. Additionally, the sports confidence questionnaire was adapted from those used by Park (2019) and Choi (2010) and modified for this study. Specifically, the achievement goal orientation scale consists of 12 items, including 7 items for task orientation and 5 items for ego orientation. The competitive state anxiety scale is composed of 10 items, with 5 items measuring physical state anxiety and 5 items measuring cognitive state anxiety. Sports confidence is a single-factor scale consisting of 7 items. All items are rated on a 5-point Likert scale, where higher scores indicate a more positive evaluation of each factor.

To verify the validity of the Achievement Goal Orientation scale, an Exploratory Factor Analysis (EFA) was conducted, and the results are presented in Tables 2 and 3. Maximum likelihood estimation was used for factor extraction, and the direct oblimin method was applied for rotation. The criterion for determining the number of factors was set to an eigenvalue of 1.0 or higher. Items with a factor loading below .40 were removed from the factors. Specifically, one task-oriented item and four ego-oriented items from the Achievement Goal Orientation subscales were removed, resulting in a total of 10 items. Additionally, two physical state items from the Competitive State Anxiety subscale were removed, resulting in a total of 9 items.

The results showed that the KMO value for the Achievement Goal Orientation scale was .843, and Bartlett's test of sphericity was statistically significant with χ^2=1249.246, df=45, p<.001, explaining 63.233% of the total variance. For the Competitive State Anxiety scale, the KMO value was .867, and Bartlett's test of sphericity was statistically significant with χ^2=1837.694, df=36, p<.001, explaining 72.409% of the total variance. These results indicate that the scales for Achievement Goal Orientation and Competitive State Anxiety are appropriate for the exploratory factor analysis model.

The reliability of the research instruments used in this study was verified by calculating the Cronbach's α coefficient, which indicates internal consistency. The results are shown in Table 4. The Cronbach's α coefficients for all sub-factors of service quality and the learning transfer factor ranged from .808 to .821. As Cronbach's α values of .60 or higher are considered

to indicate satisfactory reliability, all factors in this study were deemed to have satisfactory reliability.

Table 2. Results of Exploratory Factor Analysis on Achievement Goal Orientation

Variable		Task Orientation	Self-Orientation
Task Orientation	Task Orientation 6	.811	-.043
	Task Orientation 4	.768	-.052
	Task Orientation 5	.693	.036
	Task Orientation 3	.672	.037
	Task Orientation 7	.647	-.015
	Task Orientation 2	.639	-.144
Self-Orientation	Ego Orientation 1	-.041	.823
	Ego Orientation 2	-.007	.799
	Ego Orientation 3	-.037	.780
	Ego Orientation 5	-.039	.706
Eigenvalue		3.507	2.816
Variance Ratio (%)		35.074	28.159
Cumulative Variance (%)		35.074	63.233

The KMO value was .843, and Bartlett's test of sphericity showed χ^2=1249.246, *df*=45, *p*<.001

Table 3. Results of Exploratory Factor Analysis on Competitive State Anxiety

Variable		State Orientation	Individual Orientation
Physical State	Physical State 1	.931	.587
	Physical State 3	.856	.487
	Physical State 5	.855	.589
	Physical State 4	.787	.549
Cognitive State	Cognitive State 1	.408	.874
	Cognitive State 2	.637	.742
	Cognitive State 5	.555	.714
	Cognitive State 3	.496	.710
	Cognitive State 4	.510	.689
Eigenvalue		5.284	1.233
Variance Ratio (%)		58.712	13.697
Cumulative Variance (%)		58.712	72.409

The KMO value was .867, and Bartlett's test of sphericity showed χ^2=1837.694, *df*=36, *p*<.001

Table 4. Reliability Test Results

	Variable	Cronbach's α
Achievement Goal Orientation	Ego Orientation	.821
	Task Orientation	.817
Competitive State Anxiety	Physical State	.808
	Cognitive State	.809
Sports Confidence		.810

3. Data Analysis

To verify the validity and reliability of the research instruments used in this study, the SPSS 25.0 program was utilized. Specifically, frequency analysis was conducted to identify the general characteristics of the participants, and exploratory factor analysis (EFA) was performed to examine the validity of the research instruments. Cronbach's α coefficient was calculated to assess reliability. In addition, correlation analysis was conducted to investigate the relationships between variables, and multiple regression analysis was performed to examine the effect of achievement goal orientation on competitive state anxiety.

Subsequently, the PROCESS Macro for SPSS was used to analyze the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety. The moderating effect refers to the phenomenon where the direction and magnitude of the relationship between the dependent and independent variables are altered by a third variable, known as the moderating variable (Bae, 2015). In this study, the moderating effect was analyzed using the method proposed by Hayes (2018).

III.Research Results

The purpose of this study is to investigate the relationship between achievement goal orientation and competitive state anxiety among Korean judo athletes, and to verify the moderating effect of sports confidence on this relationship. The research results are as follows.

1. Correlation Between Achievement Goal Orientation, Competitive State Anxiety, and Sports Confidence

The results of the correlation analysis between the variables of achievement goal orientation (ego orientation and task orientation), sports confidence, and competitive state anxiety (cognitive state and physical state) are presented in Table 5. Ego orientation and cognitive state showed a significant positive correlation with $r = .134$ ($p < .05$). Ego orientation and physical state also showed a significant positive correlation with $r = .127$ ($p < .05$). However, the correlation between ego orientation and sports confidence was not significant, with $r = .105$ ($p > .05$). Task orientation and cognitive state showed no significant correlation, with $r = .100$ ($p > .05$). Task orientation and physical state also showed no significant correlation, with $r = .090$ ($p > .05$). The correlation between task orientation and sports confidence was not significant, with $r = -.112$ ($p > .05$). Additionally, no significant correlation was found between cognitive state and sports confidence ($r = .008$, $p > .05$), or between physical state and sports confidence ($r = .010$, $p > .05$).

Table 5. Results of Correlation Analysis Between Variables

	Ego Orientation	Task Orientation	Cognitive State	Physical State	Sports Confidence
Ego Orientation	**1**				
Task Orientation	-.037	**1**			
Cognitive State	.134*	.100	**1**		
Physical State	.127*	.090	.965*	1	
Sports Confidence	.105	-.112	.008	.010	1

* $p<.05$

2. The Effect of Achievement Goal Orientation on Competitive State Anxiety

The results of the multiple regression analysis on the effect of achievement goal orientation on competitive state anxiety are presented in Table 9. The effect of achievement goal orientation (ego orientation and task orientation) on the cognitive state, a sub-factor of competitive state anxiety, showed that ego orientation (β = .134, t = 2.332, p < .05) had a significant effect, while task orientation (β = .105, t = 1.837, p > .05) did not have a significant effect. Similarly, the effect of achievement goal orientation (ego orientation and task orientation) on the physical state, another sub-factor of competitive state anxiety, showed that ego orientation (β = .130, t = 2.278, p < .05) had a significant effect, while task orientation (β = .095, t = 1.656, p > .05) did not have a significant effect.

Table 6. Results of Multiple Regression Analysis on Achievement Goal Orientation and Competitive State Anxiety

Dependent Variable	Independent Variable	*B*	*SE*	*β*	*t*	*p*	R^2	*F*
Control Variable		1.842	.432	-	4.262	.000	-	-
Cognitive State	Ego Orientation	.160	.067	.134	2.332	.017	.029	4.427
	Task Orientation	.158	.086	.105	1.837	.067		
Control Variable		1.847	.425	-	4.306	.000	-	
Physical State	Ego Orientation	.151	.066	.130	2.278	.023	0.25	3.832
	Task Orientation	.142	.086	.095	1.656	.099		

* *p*<.05,

Table 7. Moderating Effect of Sports Confidence

Variable	*β*	*SE*	*t*	*p*	LLCI*	ULCI**
Control Variable	3.0279	.0487	62.1350	.0000	2.9320	3.1238
Achievement Goal Orientation	.3053	.1055	2.8933	.0041	.0976	.5129
Sports Confidence	.0081	.0726	.1116	.9112	-.1348	.1510
Achievement Goal Orientation × Sports Confidence	-.3120	.1571	-1.9860	.0479	-.6211	-.0028
Interaction Effect R^2	R^2		*F*		*P*	
	.0127		3.9444		.0479	
Conditional Indirect Effect	*β*	*SE*	*t*	*p*	LLCI*	ULCI**
M-1SD(-.6723)	.5150	.1487	3.4645	.0006	.2225	.8076
M(.0000)	.3053	.1055	2.8933	.0041	.0976	.5129
M+1SD(.6723)	.0955	.1499	.6369	.5247	-.1995	.3905

* Lower Level of Confidence Interval (LLCI) of Bootstrapped Indirect Effect within the 95% Confidence Interval

* * Upper Level of Confidence Interval (ULCI) of Bootstrapped Indirect Effect within the 95% Confidence Interval

3. Analysis of the Moderating Effect of Sports Confidence on the Relationship Between Achievement Goal Orientation and Competitive State Anxiety

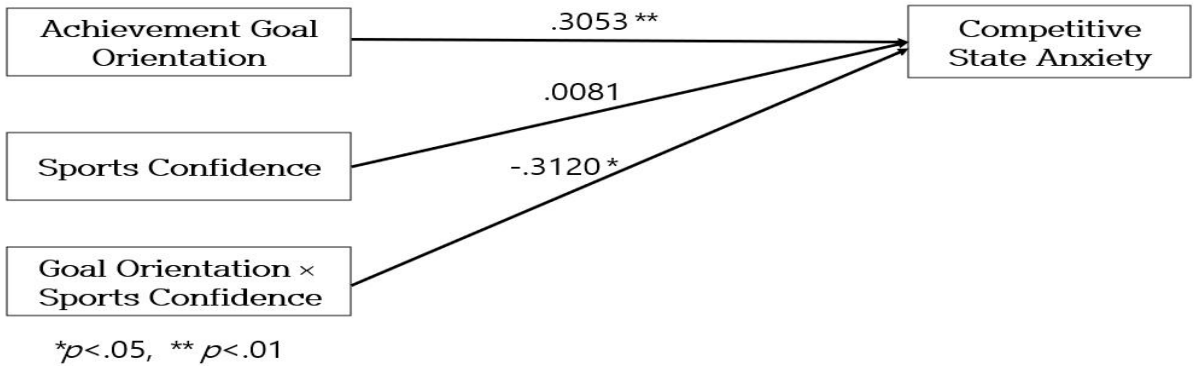

Figure 1. Statistical Model of the Moderating Effect of Sports Confidence on the Relationship Between Achievement Goal Orientation and Competitive State Anxiety

To verify the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety among Korean judo athletes, PROCESS macro Model 1, proposed by Hayes (2018), was used. Bootstrapping was set at 5,000 resamples with a 95% confidence interval. The independent variable, achievement goal orientation, and the moderating variable, sports confidence, were mean-centered. The results and model are presented in Table 7 and Figure 1.

The independent variable, achievement goal orientation, had a significant positive effect on the dependent variable, competitive state anxiety ($\beta = .3053$, $p < .01$), while the moderating variable, sports confidence, did not have a significant effect on competitive state anxiety ($\beta = .0081$, $p > .05$). The interaction between achievement goal orientation and sports confidence had a significant negative effect on competitive state anxiety, indicating a moderating effect ($\beta = -.3120$, $p < .05$). This result suggests that the effect of achievement goal orientation on competitive state anxiety varies depending on the level of sports confidence.

The change in R^2 due to the introduction of the interaction term was .0127 ($p < .05$), indicating statistical significance and confirming the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety. The analysis of the conditional effects of the independent variable on the dependent variable at specific values of the moderating variable showed that the effects were significant when sports confidence was at -.6723 (M-1SD) and .0000 (M), but not significant at .6723 (M+1SD). In other words, when sports confidence was high, the effect of achievement goal orientation on competitive state anxiety was not significant. The results of the Johnson-Neyman significance region, derived from the floodlight analysis (Spiller et al., 2013) across the full range of the moderating variable, are presented in Table 8. This analysis method allows for identifying the regions where the moderating effect is significant based on the values of the moderating variable.

The effect of achievement goal orientation on competitive state anxiety was significant only when the value of sports confidence was below .2620. When the value of sports confidence was .2620 or higher, the effect was no longer significant. In other words, sports confidence moderates the relationship between achievement goal orientation and competitive state anxiety in the region where the value of sports confidence is below .2620. The proportion of judo athletes for whom this effect was significant was 70.764%, while for 29.235% of athletes, the effect was not significant. This indicates that as achievement goal orientation increases, competitive state anxiety also increases; however, this tendency does not occur when sports confidence is high.

Table 8. Moderating Effect of Sports Confidence in the Relationship Between Achievement Goal Orientation

and Competitive State Anxiety

Sports Confidence	*β*	*SE*	*t*	*p*	LLCI*	ULCI* *
-2.1528	.9769	.3534	2.7642	.0061	.2814	1.6724
-1.9828	.9239	.3280	2.8165	.0052	.2783	1.5694
-1.8128	.8708	.3029	2.8754	.0043	.2748	1.4669
-1.6428	.8178	.2780	2.9419	.0035	.2707	1.3649
-1.4728	.7648	.2535	3.0171	.0028	.2659	1.2636
-1.3028	.7117	.2295	3.1017	.0021	.2601	1.1633
-1.1328	.6587	.2061	3.1957	.0015	.2531	1.0643
-.9628	.6056	.1837	3.2973	.0011	.2442	.9671
-.7928	.5526	.1625	3.3997	.0008	.2327	.8725
-.6228	.4996	.1433	3.4866	.0006	.2176	.7815
-.4528	.4465	.1267	3.5230	.0005	.1971	.6960
-.2828	.3935	.1141	3.4477	.0006	.1689	.6181
-.1128	.3405	.1068	3.1867	.0016	.1302	.5507
.0572	.2874	.1060	2.7124	.0071	.0789	.4959
.2272	.2344	.1117	2.0990	.0367	.0146	.4541
.2620	**.2235**	**.1136**	**1.9680**	**.0500**	**.0000**	**.4470**
.3972	.1813	.1230	1.4740	.1416	-.0608	.4234
.5672	.1283	.1387	.9252	.3556	-.1446	.4012
.7372	.0753	.1573	.4784	.6327	-.2343	.3849
.9072	.0222	.1780	.1248	.9008	-.3281	.3726
1.0772	-.0308	.2002	-.1540	.8777	-.4247	.3631
1.2472	-.0839	.2233	-.3755	.7075	-.5233	.3556

* LLCI = Lower Limit of the 95% Bootstrapped Confidence Interval for the Indirect Effect
* * ULCI = Upper Limit of the 95% Bootstrapped Confidence Interval for the Indirect Effect

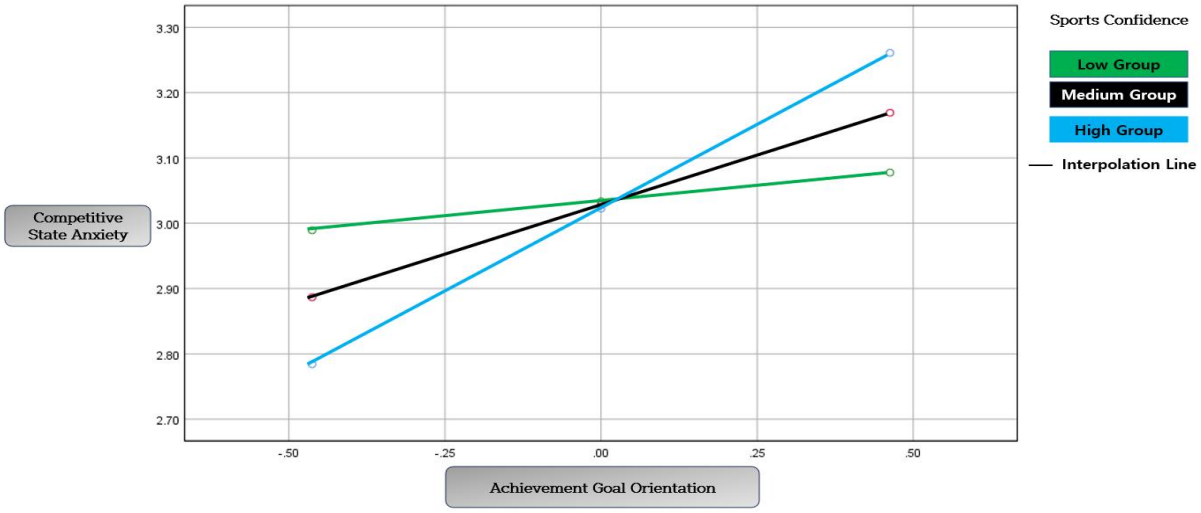

Figure 2. Analysis of the Moderating Effect of Sports Confidence on the Relationship Between Achievement Goal Orientation and Competitive State Anxiety

The moderating effect of sports confidence was found to be statistically significant, and to examine its nature, the moderating effect was visualized, as shown in Figure 2. To identify the pattern of the significant interaction, the moderating variable, sports confidence, was divided into low and high groups, and the changes in the means were analyzed. The results indicated that as sports confidence increases, the rate of increase in competitive state anxiety due to achievement goal orientation becomes more pronounced.

IV.Discussion

The purpose of this study is to investigate the effect of achievement goal orientation on competitive state anxiety among Korean judo athletes and to verify the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety. Based on the results of the study, the discussion is as follows.

First, among the sub-factors of achievement goal orientation, ego orientation was found to have a significant effect on both the cognitive state and physical state, which are sub-factors of competitive state anxiety. However, task orientation did not have a significant effect on either the cognitive state or the physical state.

Kim and Hong (2004) found that task orientation in golf players did not have a significant effect on anxiety, which supports the findings of this study. Shim (2006) revealed that ego orientation in high school judo athletes significantly affected cognitive state anxiety, which is consistent with the results of this study. Similarly, Shin (2016) found that ego orientation in marathon runners influenced cognitive state anxiety, aligning with the present findings. Lee (2018) also reported that ego goal orientation in sports billiards players affected cognitive state anxiety, which can be seen as being in line with the results of this study. Additionally, Kim (2011) found that achievement goal orientation influences competitive state anxiety, showing that top athletes, due to their higher skill levels, experience lower competitive state anxiety, whereas less skilled athletes experience higher competitive state anxiety, which also supports the findings of this study. This suggests that judo athletes with higher ego orientation also experience higher levels of cognitive state anxiety. In other words, compared to task-oriented athletes, ego-oriented athletes may experience increased cognitive state anxiety due to insufficient training and effort. Even after acquiring task-related skills and judo techniques, these athletes are likely to experience heightened physical state anxiety in competition.

Second, sports confidence was found to have a moderating effect on the relationship between achievement goal orientation and competitive state anxiety. This indicates that the effect of achievement goal orientation on competitive state anxiety varies depending on the level of sports confidence. Specifically, when the data were analyzed by categorizing sports confidence into high, medium, and low groups, it was found that as the level of sports confidence increased, the competitive state anxiety associated with achievement goal orientation also increased. Furthermore, according to the results in Figure 8, the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety was significant only when the sports confidence value was below .2620. When the sports confidence value was .2620 or higher, the effect was no longer significant. In other words, sports confidence had a positive moderating effect, indicating that as achievement goal orientation increased, competitive state anxiety also increased. This suggests that judo athletes, even after setting personal goals and mastering techniques through repeated practice, experience heightened tension as soon as they enter the competition arena. This tension may increase further if they observe other athletes competing.

Therefore, the findings of this study are supported by the research conducted by Kim Jooyoung (2013) and Kang Ryul (2013) on high school boxing athletes, Hantaejun (2008) on wrestling athletes, and Jo Younggab (2019) on badminton student-athletes, which all demonstrated that achievement goal orientation and confidence have a significant effect. Additionally, the studies by Kim Hojin (2014) and Kim Byungtae (2011) on Taekwondo athletes, and Jeon Hyunji (2000) on professional golfers, also found that sports confidence has a significant impact on competitive state anxiety, further supporting the findings of this study.

Based on the results of this study, judo coaches should first assess the level of achievement goal orientation among their athletes and provide appropriate guidance and strategies accordingly. While the technical aspects of judo are important, the focus should be on fostering moderate levels of confidence, rather than overly high confidence, to help reduce anxiety during competitions.

VI.Conclusion and Recommendations

This study examined the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety among Korean judo athletes. The conclusions drawn from this study are as follows.

First, among the sub-factors of achievement goal orientation, ego orientation was found to have a significant effect on both the cognitive state and physical state, which are sub-factors of competitive

state anxiety, while task orientation did not have a significant effect on either the cognitive or physical state. In other words, as judo athletes' ego orientation increases, their cognitive state anxiety also increases.

Second, sports confidence was found to have a moderating effect on the relationship between achievement goal orientation and competitive state anxiety. Specifically, as the level of sports confidence increases, the competitive state anxiety associated with achievement goal orientation also increases.

Based on the findings of this study, the following recommendations for future research are proposed.

First, while this study examined the moderating effect of sports confidence on the relationship between achievement goal orientation and competitive state anxiety among athletes aged 17 and older registered with the Korea Judo Association, future research should investigate how the moderating effect varies according to gender.

Second, it would be more meaningful if future research not only examines the relationship between judo athletes' achievement goal orientation and competitive state anxiety but also includes the influence of the type of judo coach.

Third, while this study focused solely on judo athletes, future research should consider conducting comparative studies involving participants from private judo gyms.

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Exploration and Practice of Integrated Teaching in Middle and High School to Enhance Nursing Students' Caring Ability and Core Competencies

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Abstract: Objective: This study aims to evaluate the impact of the integrated teaching model in middle and high schools on nursing students' caring ability and core competencies, in order to provide empirical evidence for nursing education reform and explore new ideas and methods for cultivating high-quality nursing talents. Method: A quasi-experimental research design was adopted, randomly dividing 374 nursing students into an experimental group (176 people) and a control group (198 people). The experimental group adopted an integrated teaching model, while the control group used a traditional teaching model. Before and after the teaching intervention, the Caring Ability Scale and the Core Competency Scale for Registered Nurses were used to assess student abilities, and the theoretical exam scores and practical operation scores of both groups were collected for comprehensive evaluation. Results: Before the intervention, there were no statistically significant differences in various ability indicators between the two groups, indicating that the baseline levels of the two groups were comparable. After the intervention, the experimental group significantly outperformed the control group in indicators such as nursing caring ability, cognition, courage, patience, registered nurse competency, research ability, clinical nursing, leadership, interpersonal relationships, ethical and legal practice, professional development, and education and consultation ($p<0.05$). Additionally, the experimental group also achieved significantly better scores in 7 core courses and nursing operational skills compared to the control group. Although the median difference in anatomy scores did not reach statistical significance, the pass rate of the experimental group was slightly higher than that of the control group, with a chi-square test $P=0.017$ ($p<0.05$), indicating that the difference in pass rates for anatomy scores between the two groups was statistically significant. Conclusion: The integrated teaching model in middle and high schools can effectively enhance nursing students' caring ability and core competencies, positively impacting nursing education. This teaching model, through the close integration of theory and practice, improves students' learning interest and comprehensive abilities, providing a new method for cultivating nursing talents with high quality and a spirit of humanistic care.

Keywords: Integrated Teaching in Middle and High Schools, Nursing Education, Students' Caring Ability, Core Competencies

The "National Nursing Development Plan (2021-2025)" points out that there is a gap between nursing service supply and the diverse needs of the public, with weak service capabilities in grassroots medical institutions, urgently requiring an increase in the number of nurses and the expansion of nursing service connotations [1]. The nursing profession is listed as a national shortage talent profession, with a prominent global shortage of nursing personnel and severe imbalance in the doctor-nurse ratio. Against this background, the modern vocational education system emphasizes the organic connection between middle and high vocational education, enhancing students' comprehensive quality and cultivating high-skilled comprehensive talents to meet the needs of medical institutions and improve students' employment rates

[2]. The integrated training model for middle and high schools is of great significance for the sustainable development of vocational education and maintaining social stability, while also needing to construct a modern vocational education system that reflects the concept of lifelong education.

The nursing staff in secondary vocational schools are the main force in grassroots medical institutions. The nursing discipline urgently needs to cultivate compound nursing skill talents that meet grassroots needs, contributing to the construction of a healthy China. The caring ability and core competencies of nursing staff directly affect patient recovery and the quality of care, making them essential qualities. Foreign nursing schools have incorporated the cultivation of core competencies for nursing students into their teaching objectives, but domestic research shows that the core competencies and humanistic care abilities of nursing students still need improvement, necessitating deepening of teaching reforms.

Currently, although some scholars at home and abroad have explored the integrated training model and curriculum connection for secondary and higher vocational education, research on the integrated curriculum system for nursing professionals in this context mostly remains at the theoretical level, especially with few reports on the "3+2" integrated training curriculum system. Research on the impact of this model on nursing students' caring abilities and core competencies is also relatively scarce.

This study uses a quasi-experimental design to explore the impact of the integrated teaching model on the caring abilities and core competencies of nursing students in secondary and higher vocational education, assessing its effectiveness in nursing education, providing empirical evidence for nursing education reform, and offering new ideas for cultivating high-quality nursing talents.

1. Research Methods

1.1. Research Design

This study adopts a quasi-experimental research design, using a comparative method to assess the impact of traditional teaching models and integrated teaching models on students' caring abilities, core competencies, and other related indicators. The study sets up a control group and an experimental group, with the control group using the traditional teaching model and the experimental group using the integrated teaching model, and evaluations conducted before and after the teaching intervention.

1.2 Research Subjects

Control Group: A total of 198 students from classes 44-47 of the 2020 cohort of our school, using the traditional teaching model.

Experimental Group: A total of 176 students from classes 49-51 of the 2022 cohort, using the integrated teaching model.

Inclusion Criteria: The students and their parents (or guardians) must be informed and consent to participate in this study, voluntarily joining the research project, with no significant physical or psychological disabilities; students must be regularly attending classes without long-term absences (such as exceeding a certain number of hours due to illness or personal matters), ensuring they can fully receive the teaching intervention and participate in evaluations on time before and after the intervention, thus ensuring the integrity and validity of the data.

Exclusion criteria: There are serious learning disabilities (such as intellectual disabilities, reading disabilities, etc.) that may affect the understanding of teaching content and learning outcomes, thereby interfering with the accuracy of the comparison between the integrated teaching model and the traditional teaching model. There are serious psychological issues (such as depression, anxiety, etc.) that may affect their performance in the assessment of caring abilities and core competencies. During the teaching intervention process, individuals may withdraw from the study for personal reasons (such as transferring schools, dropping out, etc.), making it impossible to complete the entire teaching intervention and subsequent evaluation process.

1.3 Research Tools

1.3.1 General Information Questionnaire: Designed by the researcher, the content includes personal factors such as gender.

1.3.2 Care Ability Assessment

The care ability assessment is conducted using the Care Ability Scale, which was developed by American nursing scholar Nkongho in 1990 as a tool to evaluate the care ability of nursing staff. The scale includes three dimensions: cognition, courage, and patience, with a total of 37 items. The scale employs a 7-point Likert scoring method, assigning scores from 1 to 7 ranging from "strongly disagree" to "strongly agree." Among the 37 items, 13 require reverse scoring, with higher scores indicating stronger care ability. The Cronbach's α coefficient for this scale is 0.84, while in this study, the Cronbach's α coefficient is 0.92.

1.3.3 Core Competency Assessment

The Chinese Registered Nurse Core Competency Scale is used, which was developed by Liu Ming from the Macao Polytechnic Institute's Nursing Department. This scale includes seven dimensions: critical thinking, clinical nursing, leadership, interpersonal relationships, ethics and legal practice, professional development, and education and training. It employs a 5-point Likert scoring method, with scores of 0 for no ability, 1 for basic ability, and 4 for high ability. There are no reverse scoring items in this scale. The overall reliability of the scale, measured by Cronbach's α, is 0.89, while in this study it is 0.95, indicating that it can reliably measure the core competencies of registered nurses.

1.4 Teaching Implementation

1.4.1 Control Group: Traditional Teaching Model

The teaching model of the control group follows the traditional segmented model of "theoretical teaching + practical teaching," executing the original talent training program during the vocational education stage and the higher vocational talent training program during the higher vocational stage. This model divides the teaching process into two main phases:

(1) Theoretical Teaching Phase: In this phase, students primarily learn the theoretical knowledge of the nursing profession systematically through classroom lectures, textbook study, discussions, and case analyses. This phase focuses on the imparting and understanding of theoretical knowledge, laying a solid theoretical foundation for the students.

(2) Practical Teaching Stage: After the completion of theoretical teaching, students enter the practical teaching stage. In this stage, students apply theoretical knowledge to practical operations through activities such as simulated laboratory operations, clinical internships, and skills training. Practical teaching focuses on cultivating students' clinical skills and operational abilities. By simulating clinical environments, students can practice and consolidate their nursing skills in a safe environment.

1.4.2 Experimental Group: Integrated Teaching Model

The experimental group adopts the "Teach-Learn-Do Integration" and "Theory-Virtual-Practice Integration" models, closely combining theory with practice to enhance the professional abilities of nursing students. The specific implementation strategies are as follows:

1.4.2.1 Establishing Organizational Structure: In 2022, the Nuclear Industry Health School signed a "Cooperative Education Agreement" with Changsha Health Vocational College to carry out a five-year integrated nursing program. A three-two segmented system is adopted, with the first three years at the Nuclear Industry Health School and the last two years at Changsha Health Vocational College. Both parties jointly formulate the talent training program and establish a leadership group and an implementation group to ensure the smooth execution of the teaching plan.

1.4.2.2 Establishing an Integrated Curriculum System for Secondary and Higher Vocational Education

(1) Clearly defined progressive training objectives: The secondary vocational stage focuses on basic courses and fundamental skills training, while the higher vocational stage emphasizes the deepening of professional knowledge and the enhancement of comprehensive practical abilities.

(2) Constructing a systematic and coherent curriculum system: Implementing modular design for courses, dividing nursing courses into four major modules: cultural, public foundation, professional foundation, and specialized courses. This ensures that the course content is systematic and coherent, with anatomy in the secondary vocational stage laying the foundation for learning in the higher vocational stage, achieving knowledge progression and avoiding repetition.

(3) Establishing unified curriculum standards: The two schools jointly formulate unified curriculum standards, clarifying the teaching objectives, content, methods, and evaluation for both secondary and higher vocational stages, ensuring the coherence of the curriculum system. Through six discussions, the talent training program for secondary and higher vocational education has been revised, including internships and course arrangements, establishing the "3+2" model aimed at enhancing students' core job competencies.

(4) Optimizing the structure of course content: Based on students' career development paths, the course content is divided into basic courses, core professional courses, and expanded courses. The course content is modularized, with each module corresponding to specific professional competency requirements. For example, in the nursing program, courses can be divided into basic nursing modules, specialized nursing modules, and comprehensive nursing modules. The secondary vocational stage mainly completes the basic nursing module, while the higher vocational stage focuses on specialized nursing and comprehensive nursing modules.

(5) Sharing teaching resources: Secondary and higher vocational institutions cooperate to establish curriculum standards, ensuring teaching continuity through online and offline communication. Both parties establish a teacher exchange mechanism, with 54 teachers exchanged within two years, jointly training faculty, and co-building a teaching resource library to enhance teaching quality. To improve the efficiency of teaching resource utilization, both schools establish a resource sharing mechanism covering textbooks, courseware, and practical training resources. Cooperation optimizes resource allocation, establishing a nursing professional teaching resource library, and applying for a national nursing professional resource library in 2023. By March 2025, the resource library serves 12.7665 million users, with 51 courses launched, 4021 original teaching materials created, and an originality rate of 82.57%. The school-enterprise cooperation has developed six dual-system textbooks, integrating vocational qualification assessments, allowing students to obtain academic certificates while also acquiring vocational qualification certificates, such as the nursing practice qualification.

(6) Constructing an Integrated Evaluation System: An evaluation system covering the entire profession is established to break the evaluation barriers between secondary vocational education and higher vocational education. The "Management System for Evaluation of Integrated Teaching between Secondary and Higher Vocational Education," the "Implementation Plan for Mid-term Inspection of Integrated Teaching between Secondary and Higher Vocational Education," and the "Implementation Plan for Assessment of Transition between Secondary and Higher Vocational Education" have been formulated.

1.5 Evaluation Methods

1.5.1 Assessment of Caring Ability and Core Competencies

Using a questionnaire survey method, assessments were conducted on two groups of students at the beginning of the first semester and after the sixth semester internship, utilizing the Caring Ability Scale and the Core Competency Scale for Registered Nurses in China to understand the caring ability and core competencies of both groups before and after implementation.

1.5.2 Comprehensive Teaching Effectiveness Assessment

(1) Theoretical Assessment: After the course concludes, a unified closed-book examination will be organized to assess seven core courses: Human Anatomy, Basic Physiology, Nursing Pharmacology, Internal Medicine Nursing, Surgical Nursing, Obstetrics and Gynecology Nursing, and Pediatric Nursing. The total score is 100 points, with 60 points as the passing mark, to evaluate the theoretical performance levels of both groups of students.

(2) Practical Skills Assessment: Before the end of the fourth semester, practical abilities will be assessed through simulated clinical operation examinations, including projects such as cardiopulmonary resuscitation, aseptic techniques, oxygen administration, and vital signs measurement. Two teachers will independently score the assessments, and the average score will be taken, with a full score of 100 points, to evaluate the practical skills levels of both groups of students.

1.6 Statistical Methods

When comparing the differences in caring ability and core competencies between the two groups, independent sample t-tests or Mann-Whitney U tests will be selected based on the characteristics of the data distribution. When comparing the comprehensive teaching effectiveness assessments between the two groups, the collected data will be entered into an Excel spreadsheet after double-checking, and SPSS 23.0 software will be used to organize the data. Multivariate analysis will be employed to compare the differences in scores between the two groups, and the pass rate will be analyzed using the chi-square test. For missing data, multiple imputation methods will be used to ensure the reliability of the analysis results. A significance level of $P<0.05$ will be considered statistically significant.

1.7 Ethical Guidelines

To ensure the rights of the research subjects, the purpose and details of the study were clearly explained before the initiation of the research, and consent was obtained from the participants and their guardians. The collected information will be processed anonymously and will only be used for this study. Participants have also been informed that the relevant data will be destroyed three years after the completion of data collection. Subsequently, questionnaires will be distributed to the consenting participants, who will fill them out independently. The questionnaire completion process will be conducted anonymously, emphasizing the principle of voluntary submission. Students who do not wish to participate have the right to choose not to submit the questionnaire.

2 Results

2.1 General Characteristics of Research Subjects

The initial sample of this study included 374 nursing students, with 176 in the experimental group and 198 in the control group. During the experiment, due to reasons such as dropout, a total of 371 students completed the comprehensive test (174 in the experimental group and 197 in the control group). In the questionnaire survey phase, a total of 348 valid questionnaires were collected (158 from the experimental group and 190 from the control group), resulting in a validity rate of 93.8%. Among all participants, there were 18 males (5.77%) and 294 females (94.23%). This gender distribution reflects the characteristic of a higher proportion of females among nursing students.

2.2 Comparison of Humanistic Care Ability and Core Nursing Ability of Two Groups of Students Before Integrated Teaching Implementation

Before the implementation of integrated teaching, a questionnaire survey was conducted on the care ability and core ability of the two groups of students. The survey showed that there were no statistically significant differences ($p>0.05$) between the two groups in terms of nurse care ability, cognition, courage, patience, registered nurse ability, research ability, clinical nursing, leadership, interpersonal relationships, ethics and legal practice, professional development, education, and consultation before the experiment began, indicating that the baseline levels of the two groups of students were comparable (see Table 1 for details).

Table 1 Comparison of Humanistic Care Ability and Core Nursing Ability of Two Groups of Students Before Implementation

Indicator	Group		*t*	p
	Control Group (N = 190)	Experimental Group (N = 158)		
Nursing Care Ability	161.76±14.65	162.34±12.89	-0.366	0.714
Cognition	56.83±5.54	56.53±4.92	0.492	0.623
Courage	52.48±4.48	52.65±4.39	-0.322	0.748
Patience	52.44±9.24	53.16±8.33	-0.709	0.479
Nurse Core Competencies	201.78±42.4	201.02±43.9	0.154	0.878
Research Ability	34.08±7.29	34.09±7.26	-0.021	0.983
Clinical Nursing	30.6±6.93	30.36±7.2	0.301	0.764
Leadership Ability	35.34±7.42	35.36±7.66	-0.020	0.984
Interpersonal Relationships	27.88±6.03	27.63±6.37	0.341	0.733
Ethics and Legal Practice	28±6.14	27.84±6.36	0.218	0.828
Professional Development	20.02±4.65	20.77±4.81	-1.381	0.168
Education and Consultation	25.86±5.12	24.96±5.38	1.501	0.134

2. 3 Comparison of Humanistic Care Ability and Core Nursing Ability Before and After Integrated Teaching for the Control Group Students

In this study, the control group students were assessed for their humanistic care ability and core nursing ability before and after receiving integrated teaching. The results showed that the control group students had significant improvements in key indicators such as nursing care ability, cognition, courage, patience, registered nurse ability, clinical nursing, interpersonal relationships, ethics and legal practice, professional development, and education and consultation ($p<0.05$). Although the improvement in research ability and management ability did not reach statistical significance (research ability: $t=-1.799$, $p=0.074$; management ability: $t=-1.644$, $p=0.102$), the average scores after the experiment (research ability: 35.52±8.74; management ability: 36.68±8.67) still showed a positive trend. These results indicate that the integrated teaching model for middle and higher vocational education has a positive effect on enhancing nursing students' care ability and core competencies, providing empirical support for the application of this teaching model in nursing education (see Table 2).

Table 2 Comparison of Humanistic Care Ability and Core Nursing Ability Before and After Integrated Teaching for the Control Group Students

Indicator	Control group		t	p
	Before Implementation	After Implementation		
Nursing Care Ability	161.76±14.65	169.3±12.39	-5.514	<0.001
Cognition	56.83±5.54	59.97±7.93	-4.446	<0.001
Courage	52.48±4.48	54.53±3.45	-5.219	<0.001
Patience	52.44±9.24	54.8±5.81	-3.050	0.003
Nurse Core Competencies	201.78±42.4	214.88±49.77	-2.818	0.005
Research Ability	34.08±7.29	35.52±8.74	-1.799	0.074
Clinical Nursing	30.6±6.93	32.45±7.8	-2.521	0.013
Leadership Ability	35.34±7.42	36.68±8.67	-1.644	0.102
Interpersonal Relationships	27.88±6.03	29.27±7.04	-2.089	0.038
Ethics and Legal Practice	28±6.14	30.27±7.06	-3.398	0.001
Professional Development	20.02±4.65	23.6±5.44	-7.038	0.001
Education and Consultation	25.86±5.12	27.08±6.28	-2.091	0.038

2. 4 Integrated Teaching Implementation in the Experimental Group: Comparison of Humanistic Care Ability and Core Nursing Ability Before and After

In this study, an assessment of humanistic care ability and core nursing ability was conducted for students in the experimental group before and after receiving integrated teaching. The indicators covered aspects such as nurses' caring ability, cognition, courage, patience, registered nurse capability, research ability, clinical nursing, leadership, interpersonal relationships, ethics and legal practice, professional development, and education and consultation. The results showed that students in the experimental group significantly outperformed the control group on all indicators ($p<0.05$), indicating that integrated teaching across vocational and higher education can significantly enhance nursing students' caring ability and core competencies, providing strong support for the application of this teaching model in nursing education (see Table 3 for details).

Table 3 Comparison of Humanistic Care Ability and Core Nursing Ability Before and After Implementation in the Experimental Group

Indicator	Experimental Group		*t*	p
	Before Implementation	After Implementation		
Nursing Care Ability	162.34±12.89	175.69±11.11	-8.973	<0.001
Cognition	56.53±4.92	63.25±5.74	-9.789	<0.001
Courage	52.65±4.39	56.12±3.35	-7.279	<0.001
Patience	53.16±8.33	56.32±6.66	-3.470	0.001
Nurse Core Competencies	201.02±43.9	231.87±54.22	-4.861	<0.001
Research Ability	34.09±7.26	38.39±9.44	-3.947	<0.001
Clinical Nursing	30.36±7.2	34.34±8.46	-3.921	<0.001
Leadership Ability	35.36±7.66	38.86±9.45	-3.173	0.002
Interpersonal Relationships	27.63±6.37	32.31±7.54	-5.245	<0.001
Ethics and Legal Practice	27.84±6.36	32.69±7.64	-5.405	<0.001
Professional Development	20.77±4.81	25.65±5.75	-7.068	<0.001
Education and Consultation	24.96±5.38	29.63±6.79	-5.949	<0.001

2.5 Comparison of Humanistic Care Ability and Core Nursing Ability between Two Groups of Students after Implementing Integrated Teaching

This study compares the humanistic care ability and core nursing ability of two groups of students after implementing integrated teaching. The results indicate that the experimental group significantly outperformed the control group in key indicators such as nursing care ability, cognitive ability, courage, patience, registered nurse ability, research ability, clinical nursing,

leadership ability, interpersonal relationships, ethical and legal practice, professional development, and education and consultation ($p<0.05$). These findings support the application of the integrated teaching model in nursing education, providing empirical support for its effectiveness in enhancing students' comprehensive abilities (see Table 4 for details).

Table 4 Comparison of Humanistic Care Ability and Core Nursing Ability between Two Groups of Students after Implementing Integrated Teaching

Indicator	Group		t	p
	Control Group (N = 190)	Experimental Group (N = 158)		
Nursing Care Ability	169.3±12.39	175.69±11.11	-4.761	<0.001
Cognition	59.97±7.93	63.25±5.74	-4.235	<0.001
Courage	54.53±3.45	56.12±3.35	-4.050	<0.001
Patience	54.8±5.81	56.32±6.66	-2.134	0.034
Nurse Core Competencies	214.88±49.77	231.87±54.22	-2.859	0.005
Research Ability	35.52±8.74	38.39±9.44	-2.758	0.006
Clinical Nursing	32.45±7.8	34.34±8.46	-2.027	0.044
Leadership Ability	36.68±8.67	38.86±9.45	-2.100	0.037
Interpersonal Relationships	29.27±7.04	32.31±7.54	-3.644	<0.001
Ethics and Legal Practice	30.27±7.06	32.69±7.64	-2.875	0.004
Professional Development	23.6±5.44	25.65±5.75	-3.202	0.002
Education and Consultation	27.08±6.28	29.63±6.79	-3.421	0.001

2.6 Evaluation of Comprehensive Teaching Effectiveness of Two Groups of Students

This study employed non-parametric testing methods to compare the differences in scores of students in the experimental group and the control group under the integrated teaching model for middle and higher vocational education across seven core courses and nursing practical skills. The results showed that the experimental group significantly outperformed the control group in key indicators such as basic physiology, nursing pharmacology, internal medicine nursing, surgical nursing, obstetrics and gynecology nursing, pediatric nursing, and practical skills ($p<0.05$). Although the median score difference in human anatomy between the two groups did not reach statistical significance ($Z=0.659$, $p=0.509$), the pass rate of the experimental group (86.96%) was higher than that of the control group (77.50%), and the chi-square test indicated that the difference in pass rates for anatomy between the two groups was statistically significant ($p=0.017$, <0.05). These results suggest that the integrated teaching model for middle and higher vocational education can effectively enhance students' comprehensive abilities, providing strong support for its application in nursing education (see Table 5, Table 6).

Table 5 Evaluation of Comprehensive Teaching Effectiveness of Two Groups of Students

Exam Subjects	Experimental Group (N = 174)	Control group (N = 197)	Z	p
Human Anatomy	68.00 (61.00 - 76.00)	70.00 (60.00 - 81.00)	0.659	0.509
Fundamentals of Physiology	80.73 (71.70 - 87.00)	63.84 (60.00 - 75.12)	9.285	0.000
Nursing Pharmacology	82.00 (73.00 - 87.50)	72.00 (60.00 - 80.00)	6.151	0.000
Internal Medicine Nursing	85.30 (78.94 - 90.34)	73.40 (64.00 - 80.50)	9.987	0.000

Surgical Nursing	91.50 (86.65 - 94.45)	79.00 (72.30 - 85.10)	11.070	0.000
Obstetrics and Gynecology Nursing	75.15 (65.70 - 79.70)	72.00 (64.00 - 78.00)	2.142	0.032
Pediatric Nursing	85.50 (79.00 - 91.00)	67.00 (60.00 - 76.00)	11.2433	0.0000
Operational Skills	94.20 (90.00 - 96.20)	82.00 (73.00 - 89.00)	11.2991	0.0000

Table 6 Comparison of the pass rate of anatomy between the two groups of students

(N = 174)			
	Value	Degrees of freedom	P
Pearson Chi-square	5.732°	1	0.017

3. Discussion

This study aims to evaluate the impact of the integrated teaching model on the caring ability and core competencies of nursing students. The results indicate that this teaching model significantly enhances students' abilities across multiple key indicators, which has important implications for the field of nursing education.

3.1 The integrated teaching model between secondary and higher vocational education can effectively enhance nursing students' caring abilities and core competencies.

Before the intervention, a survey was conducted on the caring abilities and core competencies of two groups of students. The survey showed that there were no statistically significant differences in various ability indicators between the experimental group and the control group, indicating that the baseline levels of the two groups of students were comparable before the experiment began, thus ensuring the reliability of the research results. After the experiment, the control group students showed significant improvements in multiple indicators, which may be attributed to the traditional teaching model, which, over time and with the accumulation of teaching experience, can also enhance students' abilities to a certain extent. However, the improvements in the experimental group were more pronounced, especially in key indicators such as nursing caring ability, cognition, courage, patience, registered nurse competency, research ability, clinical nursing, leadership, interpersonal relationships, ethics and legal practice, professional development, and education and consultation. This indicates that the integrated teaching model between secondary and higher vocational education can not only enhance students' foundational levels but also gradually optimize their humanistic caring abilities and core competencies, forming a virtuous cycle.

These results indicate that the integrated teaching model between secondary and higher vocational education can effectively enhance nursing students' core competencies, particularly in caring abilities and professional development.

3.2 The integrated teaching model between secondary and higher vocational education can effectively enhance students' theoretical and practical skills.

The research results indicate that the experimental group students performed significantly better than the control group in theoretical and practical skills assessments, especially in key courses such as basic physiology, nursing pharmacology, internal medicine nursing, surgical nursing, obstetrics and gynecology nursing, pediatric nursing, and practical skills. Although the median difference in anatomy scores did not reach statistical significance, the pass rate of the experimental group was slightly higher than that of the control group, with a P-value of 0.017 from the chi-square test, indicating that the difference in pass rates for anatomy scores between the two groups was statistically significant. This further proves the effectiveness of the integrated teaching model between secondary and higher vocational education in improving students' basic skills and knowledge mastery.

This result provides theoretical support for practical applications and serves as a reference for educators in designing related courses. Future research can further explore how this model can be integrated with nursing education practices to better serve the development of nursing education.

4. Conclusion

The results of this study are consistent with

existing literature on the impact of teaching models on enhancing nursing students' abilities [12, 13]. Multiple studies have demonstrated that more comprehensive and practical teaching models can better prepare students to face challenges in real work settings. This study further confirms this and emphasizes the effectiveness of the integrated teaching model between secondary and higher vocational education in enhancing nursing students' caring abilities and core competencies. The results of this study provide strong evidence to support the application of the integrated teaching model in nursing education. This teaching model can effectively enhance nursing students' caring abilities and core competencies, providing new ideas and methods for cultivating high-quality nursing talent.

In summary, the integrated teaching model between secondary and higher vocational education has shown significant effectiveness in enhancing nursing students' humanistic caring abilities and core competencies, and its potential for promotion can be verified through practical cases in the future.

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Investigation of the Knowledge, Beliefs, and Practices of ICU Nurses Regarding ICU-Acquired Weakness in Jining Region Hospitals at or Above the Secondary Level and Analysis of Influencing Factors

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Abstract：Objective To understand the current status of ICU nurses' knowledge and beliefs about ICU-acquired weakness (ICU-AW) in secondary and above hospitals in the Jining area, and to analyze its influencing factors, in order to provide a theoretical basis for improving the current status of ICU nurses' ICU-AW knowledge and beliefs in the Jining area, as well as for the subsequent development of ICU-AW training. **Methods** A convenience sampling method was used to select 204 ICU nurses from secondary and above hospitals in Jining City, China in September 2024, and the ICU nurses ICU-AW Knowledge, Belief, and Action questionnaire was used to investigate them.Results ICU nurses' ICU-AW knowledge score was (25.84 ± 8.20); ICU-AW attitude score was (30.08 ± 8.72); The ICU-AW behavior score was (22.02 ± 9.41). A comparison of ICU-AW knowledge scores among ICU nurses with different education levels and titles showed statistically significant differences ($P < 0.05$); ICU-AW attitude scores of ICU nurses with varying ages, education levels, and titles also demonstrated statistically significant differences ($P < 0.05$). **Conclusion** ICU nurses' knowledge and behaviors regarding ICU-AW are at a low level, while their attitudes are at a high level in ICU nurses from level II and above hospitals in the Jining area. This indicates a need for enhanced education and training for ICU nurses in ICU-AW, as well as the promotion of clinical implementation of early ICU-AW prevention.

Keywords： ICU nurse；Intensive Care Unit Acquired Weakness；Jining area；influencing factors

Intensive Care Unit Acquired Weakness (ICU-AW) refers to a clinical syndrome characterized by widespread limb weakness that occurs in critically ill patients during their hospitalization in the ICU, caused by factors not directly related to the disease. It is a common and serious complication in the ICU. The main symptoms include difficulty in weaning off ventilator support, loss of limb mobility, reduced reflex activity, muscle strength weakness, and muscle atrophy. Research shows that the incidence of ICU-AW in critically ill patients is approximately 44% to 59%. ICU-AW has a severe impact on the rehabilitation process of critically ill patients and their quality of life after discharge. The Knowledge, Attitude, and Practice (KAP) theory was proposed by Professor Mayo from Harvard University in 1960. This theoretical model has become widely used in clinical nursing due to its maturity and stability. This study applies the KAP theory model, where 'Knowledge' refers to the knowledge of ICU nurses in secondary hospitals regarding ICU-AW; 'Attitude' refers to the attitudes of ICU nurses in secondary hospitals towards ICU-AW; and 'Practice' refers to the actions taken by ICU nurses in secondary hospitals towards ICU-AW patients under the influence of their existing knowledge and attitudes.

ICU Nurses play a key role as direct caregivers for critically ill patients in preventing and reducing the occurrence of ICU-acquired weakness (ICU-AW) and improving patient recovery and other aspects. They need to have an in-depth understanding of the prevention strategies, assessment methods, and interventions for ICU-AW. However, according to domestic research findings, ICU nursing staff generally have insufficient

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awareness of ICU-AW and lack the ability to identify and address ICU-AW issues [7] .

This study aims to investigate the knowledge, beliefs, and behavioral status of ICU nurses regarding ICU-AW in the Jining area, and analyze the influencing factors to gain a deeper understanding of ICU nurses' awareness level of ICU-AW, providing a reference basis for formulatingeffective and targeted ICU nurse training programs.

1 Subjects and Methods

1.1 Study Subjects

Using a convenience sampling method, in September 2024, 204 ICU nurses from 5 secondary and higher hospitals in the Jining area of Shandong Province were selected as study subjects. According to the sample size calculation principle, sample size = variables × (5-10) × [1 + (10%-15%)]. There are a total of 31 independent variables in this study, resulting in a calculated sample size of 170-356 individuals. Considering limitations such as time and manpower, we plan to collect data from 170 individuals. Taking into account a 20% non-response rate, the sample size is increased by 20% on this basis. That is, 170 × (1 + 20%) = 204 individuals. Therefore, a total of 204 ICU nurses were included. Inclusion criteria: ① Registered nurses engaged in critical care work in the ICU; ② Independently rotating shifts, with more than 1 year of work experience in the ICU; ③ Informed consent and voluntary participation in this study. Exclusion criteria: ① Nurses who are not on duty due to sick leave, personal leave, maternity leave, or external training; ② ICU training nurses or rotating nurses; ③ Nurses who are unable to complete the questionnaire for various reasons. This study was approved by the ethics review committee of the hospital before it began.

1.2 Method

1.2.1 Survey Tools

①General Information Survey Form

Including the age, gender, education level, professional title, employment type, years of work experience, and type of ICU of ICU nurses.

② ICU Nurse ICU-AW Knowledge, Attitude, and Behavior Questionnaire

The ICU Nurse ICU-AW Knowledge, Attitude, and Behavior Questionnaire, developed by Wu Li et al. [8], was used to survey ICU nurses. This questionnaire includes three dimensions: knowledge (15 items), attitude (8 items), and behavior (8 items), totaling 31 items. The knowledge dimension includes subjective knowledge and objective knowledge. Subjective knowledge (items 1-6) has three response options for each item: 'Know', 'Know a little but not exactly', and 'Do not know', scoring 3 points, 2 points, and 1 point respectively; objective knowledge (items 7-15) has three response options: 'Correct', 'Uncertain', and 'Incorrect', scoring 3 points, 2 points, and 1 point respectively. The total score range is 15-45 points. A higher score indicates better knowledge of ICU-AW among ICU nurses. In the attitude dimension, each item has five response options: 'Strongly agree', 'Agree', 'Neutral', 'Disagree', and 'Strongly disagree', scoring 5 points, 4 points, 3 points, 2 points, and 1 point respectively. The total score range is 8-40 points. A higher score indicates a more positive attitude towards ICU-AW among ICU nurses. In the behavior dimension, the response options are: 'Always', 'Yes', 'Generally', 'No', and 'Never', scoring 5 points, 4 points, 3 points, 2 points, and 1 point respectively. The total score range is 8-40 points. A higher score indicates more behaviors implemented by ICU nurses regarding ICU-AW. The Cronbach's α coefficient of this questionnaire is 0.96, the test-retest reliability coefficient is 0.87, and the content validity is 0.92, indicating good reliability and validity.

1. 2.2 Survey Method

This survey was conducted using an online questionnaire format via Questionnaire Star. Before starting the survey, the researchers communicated with the head nurse of the ICU at the surveyed unit to explain the purpose and methods of the study in detail. With their permission, the head nurse of the department was responsible for conducting the survey, sending the Questionnaire Star link to suitable nurses via the WeChat app for completion. Each participant could only fill out the questionnaire once, and all questions in the questionnaire were mandatory. A total of 204 questionnaires were distributed, and 204 were returned. After excluding 6 invalid questionnaires, a final total of 198 valid questionnaires were obtained. The effective recovery rate of the questionnaire was 97.06%.

1.3 StatisticsAnalysis

Data entry and analysis were conducted using SPSS2 6.0 software, with measurement data expressed as (`c ±s) and analyzed using t-tests; count data expressed as rates (%) and analyzed using c 2 tests. Frequencies, composition ratios, means, and standard deviations were used to describe the general information of ICU

nurses; scores for ICU nurses' knowledge, attitudes, and behaviors regarding ICU-AW were described using (`c ± s); univariate analysis of knowledge, beliefs, and behaviors was conducted using t-tests and analysis of variance. A P-value of < 0.05 was considered statistically significant.

2 Results

2.1 General Information of ICU Nurses

Among the 198 ICU nurses surveyed, 46 nurses aged 25 and below accounted for 23.2% of the respondents, 68 nurses aged 26-30 accounted for 34.3%, 58 nurses aged 31-35 accounted for 29.3%, 19 nurses aged 36-40 accounted for 9.6%, and 7 nurses aged over 40 accounted for 3.5%; there were 38 males, accounting for 19.2%,and 160 females, accounting for 80.8%; 125 nurses had a bachelor's degree or higher, accounting for 63.1%, 60 nurses had a college diploma, accounting for 30.3%, and 13 nurses had a secondary vocational education, accounting for 6.6%; 16 nurses held a senior professional title, accounting for 8.1%, 66 nurses held an intermediate professional title, accounting for 33.3%, 72 nurses were junior (teacher) nurses, accounting for 36.4%, and 44 nurses were junior (staff) nurses, accounting for 22.2%. General information about ICU nurses is shown in Table 1.

Table 1 General Information of ICU Nurses

Item	Category	Number of People	Percentage (%)
Hospital Level	Secondary Class A	36	18.2
	Secondary Class B	44	22.2
	Tertiary Grade A	79	39.9
	Level 3, Grade B	39	19.7
Age (years)	≤ 25 years old	46	23.2
	26-30 years old	68	34.3
	31-35 years old	58	29.3
	36-40 years old	19	9.6
	> 40 years old	7	3.5
Gender	Male	38	19.2
	Female	160	80.8
Marital Status	Single	79	39.9
	Married	117	59.1
	Divorced	2	1.0
Education Level	Secondary Vocational School	13	6.6
	Associate degree	60	30.3
	Bachelor's degree or above	125	63.1
Title	Senior	16	8.1
	Intermediate	66	33.3
	Beginner (Teacher)	72	36.4

	Junior (Soldier)	44	22.2
Employment Type	In-house	44	22.2
	Outsourced	154	77.8
The ICU belongs to	comprehensive	139	70.2
	Surgery	9	4.5
	Internal Medicine	47	23.7
	Others	3	1.5
Years of nursing experience	≤ 5 years	86	43.4
	6-10 years	67	33.8
	11-15 years	35	17.7
	16-20 years	5	2.5
	> 20 years	5	2.5

2.2 ICU nurse ICU-AW knowledge, attitude, behavior scores

The total score of the ICU-AW knowledge, attitude, and behavior questionnaire for 198 ICU nurses is (77.94 ± 19.41) points. The score for the knowledge dimension is (25.84 ± 8.20) points, with the highest scoring item being 'How to assess ICU-AW patients' (2.11 ± 0.66) points; the score for the attitude dimension is (30.08 ± 8.72) points, with the highest scoring item being 'Should receive formal ICU-AW care training' (3.90 ± 1.16) points; the score for the behavior dimension is (22.02 ± 9.41) points, with the highest scoring item being 'Assessing patients' ICU-AW in clinical work' (2.89 ± 1.25) points. For a comparison of ICU nurses' knowledge, attitude, and behavior scores regarding ICU-AW, see Table 2-1 and Table 2-2.

Table 2-1 ICU Nurses' Scores on ICU-AW Knowledge, Attitude, and Behavior

Item	Score Range	Minimum Value	Maximum Value	Mean ± Standard Deviation
Knowledge Dimension (15)	14-45	15	45	25.84±8.20
Attitude Dimension (8)	8-40	10	40	30.08±8.72
Behavioral Dimension (8)	8-40	8	40	22.02±9.41
Overall (31)	30-125	35	125	77.94±19.41

Table 2-2 Scores of ICU nurses on ICU-AW knowledge, attitudes, and behaviors

Dimension	Item	Average Score ($\bar{x}$±s)	Item Total Score
Knowledge	The concept of ICU-AW	1.77±0.59	3
	Clinical manifestations of ICU-AW	2.04±0.68	3
	ICU-AWHow toDiagnose	2.09±0.69	3
	How toAssess ICU-AW Patients	2.11±0.66	3
	What are the risk factors for ICU-AW?	1.97±0.68	3

	What are the preventive measures for ICU-AW?	2.00±0.70	3
	ICU-AW is one of the common complications in critically ill patients.	1.54±0.74	3
	The occurrence of ICU-AW in critically ill patients on mechanical ventilation for more than 4 to 7 days can reach 33% to 82%.	1.56±0.71	3
	The diagnosis of ICU-AW mainly relies on the Medical Research Council score (MRC-score) for assessment.	1.65±0.73	3
	The clinical manifestations of ICU-AW patients primarily include difficulty weaning from mechanical ventilation, mild paresis or quadriplegia, reduced reflexes, and muscle atrophy.	1.47±0.71	3
	ICU-AW not only prolongs the length of hospital stay and increases medical costs, but it is also more likely to decrease patients' functional ability and survival rates.	1.46±0.74	3
	Muscle weakness and functional impairment are still very common among ICU survivors one year after discharge.	1.57±0.73	3
	Bradycardia may be an important risk factor for ICU-AW.	1.52±0.75	3
	Early mobilization of ICU patients is the most effective intervention to prevent or mitigate ICU-AW.	1.47±0.74	3
	Standard insulin therapy can reduce the incidence and duration of neuromuscular complications, thereby alleviating ICU-AW.	1.61±0.76	3
Attitude	Knowledge related to one's own ICU-AW needs to meet clinical requirements.	3.57±1.31	5
	ICU nurses should dynamically observe the patient's ICU-AW status	3.85±1.21	5
	Formal ICU-AW care training should be received	3.90±1.16	5
	Nurses should take on the responsibility of assessing ICU-AW care work	3.75±1.12	5
	Early functional exercise is very important for the prevention and recovery of ICU-AW	3.86±1.23	5
	Healthcare personnel should prioritize the prevention of ICU-AW just as they do with other symptoms (such as delirium).	3.85±1.22	5
	It is necessary to educate patients or their families about ICU-AW-related knowledge in clinical practice.	3.70±1.31	5
	The ICU-AW status of critically ill patients should be included in the handover content of clinical work.	3.60±1.26	5
Behavior	Actively pay attention to the patient's ICU-AW status in clinical work	2.80±1.26	5
	Communicate with patients about limb muscle strength in clinical work	2.73±1.33	5
	Assessment of patients' ICU-AW in clinical practice	2.89±1.25	5
	Timely feedback to the department's doctors regarding the patient's muscle strength status	2.63±1.31	5
	Provide effective early functional exercise for critically ill patients	2.77±1.24	5
	Guide family members to help patients engage in appropriate activities to alleviate symptoms such as physical fatigue	2.67±1.21	5
	Timely evaluation of nursing interventions for early patient mobilization	2.73±1.22	5
	Accumulation of knowledge related to ICU-AW during work processes	2.80±1.23	5

2.3 Comparison of ICU-AW knowledge, attitudes, and behavior scores among ICU nurses with different characteristics

The results of the one-way ANOVA indicate that there are statistically significant differences in ICU-AW knowledge scores among ICU nurses with different educational backgrounds and titles ($P < 0.05$).

Among different age groups of nurses, those over 40 years old had the highest knowledge scores, while nurses aged 26-30 had the lowest. Among different educational groups, nurses with a bachelor's degree or higher had the highest knowledge scores, while those with a secondary vocational education had the lowest.

Comparison of ICU-AW knowledge, attitudes, and behavior scores among ICU nurses with different characteristics see Table 3.

Table 3 Comparison of ICU-AW knowledge, attitudes, and behavior scores among ICU nurses with different characteristics

Item	Category	Knowledge Score ($\bar{x}\pm s$)	Attitude Score ($\bar{x}\pm s$)	Behavior Score ($\bar{x}\pm s$)
Age (years)	≤25 years old	25.48 ± 10.60	33.59 ± 8.23	21.17 ± 11.55
	26-30 years old	24.62 ± 7.44	29.54 ± 8.27	20.78 ± 9.39
	31-35 years old	26.72 ± 7.43	28.40 ± 8.96	24.40 ± 7.80
	36-40 years old	27.05 ± 6.30	28.16 ± 10.23	21.42 ± 8.59
	> 40 years old	29.57 ± 7.72	31.29 ± 3.45	21.57 ± 6.75
FValue		1.035	2.828	1.345
Pvalue		0.39	0.026	0.255
Gender	Male	24.42±7.43	30.34±8.09	23.50±9.66
	Female	26.18±8.36	30.01±8.89	21.67±9.35
t value		-1.190	0.209	1.078
Pvalue		0.235	0.835	0.282
Marital Status	Single	25.15±9.25	31.33±8.34	21.39±10.33
	Married	26.30±7.48	29.26±8.96	22.47±8.83
	Divorced	26.50±3.54	28.50±6.36	20.50±4.95
FValue		0.465	1.369	0.333
Pvalue		0.629	0.257	0.717
Education Level	Secondary Vocational School	18.77±6.43	23.92±9.09	17.62±11.05
	Associate degree	26.12±10.17	32.37±8.50	21.30±10.75
	Bachelor's degree or above	26.45±6.93	29.62±8.47	22.82±8.43
FValue		5.443	5.740	2.077
Pvalue		0.005	0.004	0.128
Title	Senior	31.13±12.10	36.19±4.86	24.81±11.52
	Intermediate	26.48±7.91	31.12±8.73	22.45±9.71
	Beginner (Teacher)	26.10±8.15	29.10±8.81	22.46±9.18
	Junior (Soldier)	22.55±5.55	27.89±8.66	19.64±8.30
FValue		5.031	4.374	1.521
Pvalue		0.002	0.005	0.210
The ICU belongs to	comprehensive	25.18 ± 6.92	28.23 ± 8.99	21.77 ± 8.72
	Surgery	26.00 ± 6.71	30.78 ± 6.26	24.44 ± 6.06
	Internal Medicine	28.11 ± 11.28	35.55 ± 5.09	22.40 ± 11.74
	Others	20.67 ± 4.51	27.67 ± 14.57	20.33 ± 10.97
FValue		1.922	9.417	0.287
Pvalue		0.127	0.000	0.835

Years of nursing experience	≤5 years	24.88 ± 8.82	30.73 ± 8.41	21.12 ± 10.10
	6-10 years	25.99 ± 7.84	29.52 ± 9.22	22.39 ± 9.36
	11-15 years	26.77 ± 7.35	28.97 ± 9.53	23.83 ± 8.41
	16-20 years	29.40 ± 7.16	32.80 ± 4.21	18.40 ± 5.68
	> 20 years	30.40 ± 8.08	31.20 ± 4.21	23.60 ± 7.02
FValue		1.033	0.467	0.763
Pvalue		0.392	0.760	0.550

3 Discussion

3.1 The knowledge level of ICU nurses in secondary and above hospitals in Jining regarding ICU-AW is relatively low

The results of this study show that the knowledge score of ICU nurses in secondary and above hospitals in Jining regarding ICU-AW is (25.84 ± 8.20) points (with a total knowledge dimension score range of 14-45 points), indicating that the knowledge level of ICU nurses in this region regarding ICU-AW is low. This is consistent with the findings of Cai Yuqing [9] and Yao Yanrong [10]. From the scores of each item, the highest score was for 'how to assess ICU-AW patients' (2.11±0.66), indicating that ICU nurses are aware of the assessment methods for the frail state of critically ill patients. The lowest scoring item was 'ICU-AW not only prolongs the patient's hospital stay and increases medical costs but is also likely to decrease the patient's functional ability and survival rate' (2.11±0.66), indicating that ICU nurses in this region do not understand the relevant knowledge of ICU-AW and do not pay enough attention to its hazards. This is related to the fact that ICU nurses in this region have not received relevant training on ICU-AW and have insufficient awareness of its potential dangers. Similar results were found in Zhao Xin's study [11]. A comparison of ICU-AW knowledge scores among ICU nurses with different educational backgrounds and titles showed statistically significant differences ($P<0.05$). Since research on ICU-AW in China started relatively late, coupled with the slow pace of updates in nursing textbooks, ICU nurses have had little exposure to relevant content on ICU-AW during their formal education, and they can only learn this knowledge through professional training after starting work. Nurses with higher education levels have relatively more avenues to acquire knowledge and stronger clinical thinking abilities, thus performing better in knowledge scores than those with lower education levels. Research shows [12] that the promotion of nurses' positions not only helps enhance their professional quality but also promotes the overall improvement of nurses' capabilities. Nurses with senior titles not only accumulate rich clinical practice experience but also possess a more complete knowledge system. Additionally, they participate in doctors' rounds, case discussions, and academic exchanges more frequently than general nurses, providing them with more opportunities to encounter and master new knowledge [13]. Therefore, their knowledge of ICU-AW is better than that of nurses with other titles.

3.2 ICU nurses in level two and above hospitals in Jining have a relatively positive attitude towards ICU-AW.

The results of this study show that the attitude score of ICU nurses in level two and above hospitals in Jining towards ICU-AW is (30.08±8.72) points (the total score range for the attitude dimension is 8-40 points), which is the highest score among the dimensions surveyed.

This indicates that ICU nurses in this region have a relatively positive learning attitude towards ICU-AW, and it also reflects their enthusiasm for receiving training related to ICU-AW. The comparison of ICU-AW attitude scores among ICU nurses of different ages, education levels, and professional titles shows statistically significant differences ($P<0.05$). Among them, the item 'should receive formal ICU-AW nursing training' scored the highest (3.90±1.16), further demonstrating the high demand for systematic training in ICU-AW among ICU nurses in this region. Song Qingna et al. conducted a survey on the cognitive status of ICU nurses regarding ICU-AW in a certain tertiary general hospital, and the results found that ICU nurses have a serious lack of knowledge about ICU-AW, but their attitude is relatively positive, which is basically consistent with the results of this study. ICU nurses hold a positive attitude towards enhancing their own education and improving professional skills such as the identification of ICU-AW, and this self-improvement can lay a good foundation for

implementing various measures to prevent ICU-AW in clinical practice. In the theory of knowledge, belief, and action, the transformation of beliefs is a key element. Through independent thinking and reflection on knowledge, individuals can convert what they have learned into their own beliefs and attitudes, which in turn guide and drive personal behavior. Nursing managers should regard the positive beliefs of ICU nurses as a foundation, strengthen the knowledge education of ICU-AW, and promote the formation of good professional behavior habits among nurses.

3.3 ICU nurses in level two and above hospitals in Jining engage in behaviors related to the implementation of ICU-AW less frequently.

The results of this study show that the ICU nurses in level two and above hospitals in Jining have an ICU-AW behavior score of (22.02±9.41) points (with a total score range of 8-40 points). This indicates that ICU nurses in this region implement behaviors related to ICU-AW patients less frequently, which is consistent with the findings of Wang Ying et al. [17]. Among the items, the score for 'timely reporting the patient's muscle strength status to the attending physician' was the lowest (2.63±1.31), indicating that nurses communicate less with doctors regarding patients' ICU-AW, and their level of awareness regarding ICU-AW is insufficient. The analysis suggests that this may be due to the busy nature of ICU work, where nurses may overlook the observation of patients' muscle strength and the intervention or education regarding limb activity. Additionally, nurses' insufficient knowledge and limited understanding of ICU-AW prevent them from fully recognizing its importance, resulting in fewer behavioral changes in nursing practice. Consequently, preventive measures for ICU-AW patients are relatively scarce. For critically ill patients, initiating early mobilization can effectively prevent complications such as ICU-AW and delirium, halt muscle atrophy, enhance physical function, promote lung function recovery, and improve patients' long-term quality of life [18-20]. Therefore, early mobilization for critically ill patients is particularly important. However, in this study, the low intervention behaviors of ICU nurses towards ICU-AW patients suggest that nursing managers should emphasize training for ICU nurses in this area, enhance nurses' awareness of early intervention, and improve their practical capabilities in early intervention.

4 Summary

In summary, the ICU nurses in level two and above hospitals in Jining have low scores in ICU-AW knowledge and behavior, while their attitude scores are relatively high, indicating a positive attitude towards ICU-AW. Management departments should strengthen the education and training of ICU nurses regarding ICU-AW, enhance nurses' professional knowledge and skills, and promote the implementation of various measures to prevent ICU-AW in clinical settings, thereby reducing the incidence of ICU-AW in critically ill patients.

Before the start of this study, a literature review revealed that there is currently a lack of similar research in the Jining area. This study is the first to investigate the awareness level of ICU-AW among ICU nurses in level two and above hospitals in Jining. The data collected has regional characteristics, and the results of the study can provide a reference for the specialized training of ICU nurses in this area, helping to accurately grasp the direction and focus of the training. However, this study has certain limitations in terms of the research area, and the sample size is relatively small. Future research could further expand the sample size to include ICU nurses from other cities and hospitals of different levels, in order to conduct a more extensive and in-depth investigation.

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Literature Review on the Impact of Educational Leadership on Student Academic Achievement

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Abstract: This paper systematically reviews the research progress (2000-2024) on the impact of educational leadership on student academic achievement. The review finds that the theoretical connotation of educational leadership has continuously evolved, shifting from an early focus on formal leaders (e.g., principals) to emerging perspectives emphasizing distributed leadership, teacher leadership, and learning-centered instructional leadership. Teacher leadership, as a vital branch of educational leadership, has become a research hotspot, with studies exploring its structural connotations (e.g., self-leadership, student development, professional community, school development, family education leadership), developmental characteristics (process-oriented, contextual), and enhancement pathways (empowerment, course development, practical transformation). Regarding the relationship between educational leadership and academic achievement, research indicates that the influence is indirect and complex: educational leadership (e.g., instructional leadership, teacher curriculum leadership, distributed leadership) affects students' learning attitudes, motivation, emotions, and strategies through mediating variables such as school culture, teacher motivation and behaviors, teaching strategies, curriculum implementation, technology application, and resource sharing, ultimately impacting academic achievement. Existing research primarily employs empirical methods (combining qualitative and quantitative approaches), yet exhibits limitations including insufficient and inconsistent empirical evidence, low ecological validity, lack of research on dynamic interactions and synergistic effects, and inadequate exploration of cultural factors. Future research should focus on the mechanisms of specific leadership types (e.g., teacher leadership, distributed leadership), adopt mixed methods, pay attention to contextual differences, and explore the dynamic interactions among leadership, teaching practices, student states, and academic achievement.

Keywords:Educational Leadership; Academic Achievement; Distributed Leadership; Teacher Leadership; Academic Emotions

1.Introduction

Education is the cornerstone of national development, and improving educational quality and promoting the comprehensive development of students are the core goals of educational reform. Educational leadership, as a key factor influencing school effectiveness, teaching quality, and ultimately student academic achievement, has increasingly attracted widespread attention from both academia and practice. In the face of numerous challenges in educational reform, exploring educational leadership, particularly how it affects student academic achievement, is of significant theoretical and practical importance for understanding school operational mechanisms, optimizing educational management practices, and promoting modernization and sustainable development in education. Therefore, this study focuses on the core issue of "the impact of educational leadership on student academic achievement," aiming to systematically review existing research findings, clarify the evolution of the connotation of educational leadership, its main types, mechanisms of action, and the complex relationship with student academic achievement, as well as identify the shortcomings of existing research and future directions.

The research mainly focuses on the evolution of educational leadership theories, core connotations and

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types, the role of teacher leadership, the relationship between educational leadership and student academic achievement, research methodologies, and main findings. The study is based on abstracts of 18 Chinese and English literature sources from core journals at home and abroad, covering the period from 2000 to 2024 and encompassing various research types. Through systematic reading, summarization, and integration of these abstracted information, the study aims to present the basic landscape and cutting-edge dynamics of this research field.

2.Evolution of Educational Leadership Theories and Core Connotations

Educational leadership is not a static concept; its theoretical development exhibits dynamic evolution characteristics. Research by Teng Peng et al. points out that while educational leadership theory originates from the perspective of corporate leadership, its development must be closely integrated with the practice of educational management. This study reveals through content analysis that research on educational leadership theory is predominantly empirical, utilizing both qualitative and quantitative methods, with case studies playing a key role in promoting topic development and theoretical construction. Early research may have focused more on the roles of formal leaders (such as principals) and objective job analysis, but as research deepens, the focus gradually shifts to the subjective constructions of stakeholders and increasingly centers on "learning."

Among various educational leadership theories, the theory of "distributed leadership" has gained significant attention and development in recent years. This theory posits that "leadership is not concentrated in individuals holding formal positions," advocating for the view of leadership as a practice dispersed throughout the organization, encouraging broader member participation. Understanding and practicing distributed leadership requires adopting a "gradual adjustment" perspective, adapting according to the school context, developmental needs, and member readiness, and reinterpreting the roles of formal leadership and organizational structure within it. Wu Yu explores how educational information technology leadership can promote the sharing of educational resources from the perspective of distributed leadership, suggesting that this process can be divided into three stages: initial planning, collaborative interaction, and proactive innovation, ultimately forming a bottom-up, proactive innovation atmosphere through institutional guarantees and cultural penetration. This theory has propelled research on informal leadership roles such as teacher leadership.

At the same time, "instructional leadership," as a core concept in the field of school leadership and management, continues to receive attention. Cheng Shangrong emphasizes that instructional leadership possesses profound leadership, transcendence over technology, and diversity of subjects, closely linked to culture, aiming to enhance the quality of student learning and creativity. Zhao Decheng summarizes the assessment tools for instructional leadership and points out future research directions, including guiding research with a comprehensive development concept, shifting from principal instructional leadership to shared instructional leadership, and improving the ecological validity of research.

Table 1: Summary of Major Educational Leadership Related Concepts Mentioned in Literature Abstracts

Concept of Leadership / Theory	Core Ideas / Characteristics / Dimensions (According to Abstract)	Cited Literature (Abstract Number)
Teaching Leadership	Through value leadership; transcending technical pursuits for value rationality; pluralism of subjects (teachers as leaders); emphasizing self-leadership; cultural relevance; aimed at improving student learning quality	[1], [13]
Distributed Leadership	Leadership is not concentrated in individuals with formal positions; a gradual process of involvement from formal to informal leadership; needs to be adjusted according to context; promotes resource sharing (startup, interaction, innovation stages)	[3], [10], [15]
Teacher Leadership (General)	One of the triple abilities of excellent teachers; a measure of educational vitality; includes self, nurturing, professional community, school	[3], [5], [9]

	development, and family education leadership; process-oriented, contextual, interactive, and implicit.	
Teacher Technological Leadership	Integrating technological literacy / capabilities / resource integration into leadership behaviors; promoting technology application, improving teaching, and enhancing efficiency; including dimensions such as integration, planning, assurance, management, and reflective ability.	[6]
Teacher Curriculum Leadership	Leading and guiding members in curriculum affairs (design, development, implementation, evaluation); enhancing the quality of student learning; different representations at various developmental stages (awareness, professionalism, collaboration, and critical thinking).	[11], [12], [14]
Learning-Centered Leadership	A direction for the development of teaching leadership that emphasizes learning as the core.	[13]

3. The Rise, Connotation, and Development Path of Teacher Leadership

With the popularization of distributed leadership theory and the increasing demand for teacher subjectivity in educational reform, teacher leadership has become an increasingly important branch and emerging field in educational leadership research ([3], [5], [9]). Several scholars emphasize that in the context of the new era, leveraging teacher leadership is crucial for promoting educational modernization ([5]), implementing collaborative educational reforms ([9]), deepening curriculum reform ([11], [12]), and enhancing the overall vitality of schools.

Scholars have defined the connotation and structure of teacher leadership from multiple dimensions. Zhao Mingren (2023) proposed that teacher leadership is a third capability characteristic beyond excellent teachers' learning and teaching abilities, including five dimensions: self-leadership, student development, professional community, school development, and family education leadership. The functioning of these dimensions is an important measure of regional educational vitality [5]. Zhang Rongfei and Zhao Leilei focus on the technological leadership of teachers in the intelligent era, defining it as the ability to integrate information technology into leadership behaviors, and dividing its structure into five components: integration of technology and teaching, planning ability for technology application, support capacity, management power under technological support, and reflective ability in technology application. Other scholars have explored teacher curriculum leadership, which refers to the ability of teachers to lead and guide members in curriculum matters ([11], [14]).

The development of teacher leadership is characterized by processuality and situationality, influenced by individual, group, and environmental factors [5]. Zhang Qiong and Fu Yan found through surveys that teachers at different development stages exhibit differences in their curriculum leadership representations [14]. However, the overall development of teacher leadership currently faces challenges. Zhao Mingren pointed out that the overall situation is not ideal [5], and Ye Liping and Zhu Chengke (2014) also mentioned that teachers are detached from curriculum leadership, with traditional management models hindering the enhancement of their leadership. In response to these issues, scholars have proposed corresponding improvement paths, including setting up leadership courses, transformational leadership practices [5], and empowerment [12].

4. Student Academic Achievement: Evaluation, Influencing Factors, and the Connection with Motivation Theory

The effective evaluation of student academic achievement and the study of influencing factors are quite complex. Zhang Bin and Wang Shaofei believe that the design of academic achievement report cards affects the realization of evaluation functions, suggesting a shift from "informative" to promoting learning improvement, requiring specific situations to be presented based on teaching objectives, focusing on improvement actions, accommodating student reflections, and establishing a communication and

negotiation mechanism between teachers and students [2]. However, achieving effective monitoring of academic achievement also faces challenges. Zhang Zhenzhu and Wang Yan mentioned in their review of an interview with Aaron Benavot that monitoring educational sustainable development goals is difficult and requires a transformation of monitoring mechanisms [8].

Multiple studies focus on students' psychological factors. Dong Yan and Yu Guoliang found that academic emotions have a complex impact on academic achievement, with different levels of emotional arousal having different effects [16]. The research by Wang Zhenhong and Liu Ping also revealed significant impacts of motivational factors, learning strategies, and intelligence levels on high school students' academic achievement, with some factors having direct effects and others influencing indirectly through mediating variables [18].

Table 2: Factors Related to Student Academic Achievement Mentioned in the Literature Abstracts

Influencing Factors	Relationship/Effect with Academic Achievement (According to Abstract)	Cited Literature (Abstract Number)
Design of Academic Achievement Report Card	New designs point to learning improvements, establish communication and negotiation mechanisms, provide reflection opportunities, and focus on improvement actions (indirect influence)	[2]
Teacher Educational Leadership	Shapes academic achievement through active communication, motivation stimulation, demonstration, etc. (positive influence)	[4]
Teacher Motivation	The association with student outcomes is still inconsistent and may be influenced by mediating variables such as teaching strategies	[7]
Academic Emotions	Positive low-arousal emotions directly predict positively; negative high/low-arousal emotions directly predict negatively; positive high-arousal emotions indirectly predict positively through goals, efficacy, and strategies	[16]
Motivational Factors (Students)	Self-efficacy, intrinsic motivation, and mastery goals are significantly positively correlated; extrinsic motivation and performance goals are significantly negatively correlated; self-efficacy has a direct regression effect on mastery goals; intrinsic motivation indirectly influences through learning strategies.	[18]
Learning Strategies	Significantly positively correlated with academic achievement; has a direct regression effect on academic achievement.	[18], [16]
Intelligence Level (IQ)	Significantly positively correlated with academic achievement; has a direct regression effect on academic achievement.	[18]
Monitoring of Educational Sustainable Development Goals	Monitoring difficulties and challenges in achieving goals, indirectly related to academic achievement as one of the measurement indicators.	[8]

These studies on students' intrinsic motivation and emotions are also linked to research exploring teacher behaviors and leadership. For example, Bardach and Klassen focus on the relationship between teacher motivation and student outcomes; although their conclusions are inconsistent, they suggest that teacher

motivation may influence students through teaching strategies, among other factors [7]. YuSong Liu and others apply Maslow's hierarchy of needs theory to teacher educational leadership practices, arguing that teachers shape students' academic achievements and character through positive communication, implying that the motivational state of teachers may affect leadership behaviors and students [4].

5.the pathways and complexities of how educational leadership influences student academic achievement

The relationship between educational leadership and student academic achievement is complex, with empirical research showing that its influence is indirect and mediated by multiple factors. Theoretically, educational leadership aims to promote student learning and development, as both instructional leadership and teacher curriculum leadership point towards the enhancement of student learning quality. However, in practice, leadership affects academic achievement through a series of mediating variables, such as teacher motivation, which may influence student outcomes through teaching strategies.

The perspective of distributed leadership also provides a framework for understanding this influence. When leadership is distributed among more members, it may stimulate broader participation and innovation ([10], [15]), forming a stronger professional learning community ([5]), which helps improve the overall teaching environment and practices, thereby benefiting student learning. However, research also points out the complexities and challenges involved. Bardach and Klassen particularly emphasize the inconsistency found in the relationship between teacher motivation and student outcomes, and explore the possibility of "signal loss," as well as the necessity of studying reverse effects, reciprocal effects, and dynamic interactions [7]. This suggests that the chain from leadership behavior to student academic achievement may be disrupted by various factors [5]. Zhao Decheng also highlighted the need to enhance the ecological validity of research on teaching leadership [13], which means that studies need to be closer to real school environments and consider the interactions of more complex factors.

6.Summary

Based on the summary of the above literature, we can see that current research on educational leadership and its impact on student academic achievement presents the following main characteristics and trends:

First, the concept of educational leadership has continuously evolved and deepened, shifting from an early focus on individual principals and management functions to a gradual emphasis on the teaching process and a learning-centered approach, leading to the emergence of new theoretical perspectives ([13]); secondly, teacher leadership has received significant attention ([3], [5], [9]), with research delving into its structural connotations ([5], [6], [11]), developmental representations ([14]), practical dilemmas ([12]), and enhancement pathways ([5], [9], [11], [12]); thirdly, research methodologies are primarily empirical, employing both qualitative and quantitative methods, with case studies playing an important role ([3]), while also utilizing quantitative approaches such as structural equation modeling ([16]) and regression analysis ([18]) to explore influencing factors; finally, regarding the relationship between educational leadership and student academic achievement, research tends to view this as an indirect and complex process, where leadership influences student learning attitudes, motivation, emotions, and strategies ([16], [18]) through mediating factors such as school culture ([1]), teacher motivation and behaviors ([4], [7]), teaching strategies ([7]), curriculum implementation ([11]), technology application ([6]), and resource sharing ([10]), ultimately reflecting in academic achievement.

However, the existing research (based on the provided abstract) also has some obvious shortcomings or gaps:

There is limited empirical evidence regarding the direct impact of educational leadership on student academic achievement, and the conclusions are inconsistent; the research perspectives and methods need to be expanded, with a focus on improving ecological validity and addressing dynamic interactions; there is insufficient research on the synergistic effects of different types of leadership and the differences in their effects in various school contexts; the role of cultural factors in educational leadership practices lacks in-depth empirical research.

Based on this, future research can be expanded in the following areas: First, it can focus on specific types of leadership (for example, teacher leadership or distributed leadership, which are currently hot topics) and their relationship with student academic achievement, emphasizing the exploration of specific, measurable mediating mechanisms (such as teachers' sense of teaching efficacy) to more clearly reveal the

pathways of "signal" transmission. Second, mixed research methods can be employed, combining large-scale surveys and in-depth case studies of schools to balance generalizability and contextual details. Third, particular attention can be paid to the differences in leadership practices across different contexts (such as regions with varying levels of development and different types of schools) and their similarities and differences in impacting student achievement, providing more targeted recommendations for policy formulation and practice improvement. Finally, this study will strive to capture the dynamic interactions between leadership, teaching practices, student states, and academic achievement in data collection and analysis, responding to existing research calls for exploring reciprocal effects and dynamic processes. Through these efforts, it is hoped to provide deeper, more specific, and more practical insights into the core issue of "how educational leadership can effectively promote student academic achievement."

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Research on the Innovative Development Path of Language Education from the Perspective of Digital Communication

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Abstract: In the context of the rapid development of digital technology, digital communication is profoundly changing the organizational form and content presentation of language education. Based on the connotation and characteristics of digital communication, this paper systematically analyzes the embedding path of new media platforms, artificial intelligence technologies and educational apps in Chinese classroom teaching, after-class development and evaluation mechanisms. The study pointed out that digital communication not only expands the teaching field and methodology of language education, stimulates students' interest in learning, but also promotes the improvement of core Chinese literacy. However, problems such as information fragmentation and uneven digital competence of teachers cannot be ignored. Therefore, this paper proposes an optimization path, including improving teachers' digital literacy, constructing multimodal teaching scenarios, and improving content review and data governance mechanisms, in order to provide theoretical support and practical guidance for the digital transformation of language education.

Keywords: Digital Communication; Language Education; Pedagogical Transformation; Multimodal Teaching; Core Literacy

1. Introduction

As a core discipline in the basic education system, Chinese education has always carried the multiple tasks of inheriting the excellent traditional Chinese culture, improving the ability to use language and writing, and cultivating aesthetic and humanistic qualities. With the continuous advancement of curriculum reform, the status and function of Chinese discipline have become increasingly prominent, and Chinese is no longer a simple "tool discipline", but a highly comprehensive quality education carrier. Driven by the global wave of digitalization, the rapid development of information technology represented by the Internet, big data, artificial intelligence, virtual reality, etc., has had a profound impact on the traditional education model, especially in the way of communication and learning has undergone fundamental changes. Digital communication means, as a product of the integration of technological development and education, are becoming an important driving force for educational innovation in the new era.

At present, Chinese teaching in primary and secondary schools is facing a series of challenges, such as students' lack of interest in learning, declining reading ability, and single teaching methods of teachers, all of which call for in-depth changes in teaching content, methods, and evaluation methods in Chinese education. With its advantages of interactivity, immediacy and diversity, digital communication provides the possibility to solve these problems. Through the dissemination of poems through new media platforms, the correction of essays with the help of AI technology, and the immersive experience of classical literature through virtual reality technology, Chinese education has begun to show a development trend of diversified integration and symbiosis of wisdom.

At the same time, in recent years, the Ministry of Education and local education administrative departments have vigorously promoted the construction of the "smart education" platform, and the national smart education public service platform and various regional education cloud service platforms have been continuously improved, which provides a

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solid guarantee for the sharing and dissemination of Chinese teaching resources. The deep integration of technology and education is reshaping the new ecology of the Chinese classroom by teachers accessing resources and updating teaching content through digital platforms, and students learning anytime and anywhere through digital terminals.

However, we should also be soberly aware that digital communication is not a panacea, and its application process also exposes practical difficulties such as information fragmentation, entertainment of educational content, and insufficient digital literacy of teachers. On the basis of maintaining the core values of language disciplines, how to make reasonable and effective use of digital communication means is an important issue that must be faced in the current reform of language education.

Based on the basic characteristics of digital communication methods, this paper will deeply analyze the specific application scenarios of digital communication methods in language education, and put forward operational countermeasures and suggestions based on typical problems in current educational practice, aiming to provide ideas and references for the high-quality development of language education.

2. The Connotation and Characteristics of Digital Communication Means

Digital means of communication refer to the means of information dissemination constructed by relying on digital technologies (such as the Internet, multimedia, intelligent algorithms, mobile communications, etc.), which have significant characteristics such as digitization, networking, interactivity, and personalization. It breaks through the limitations of time, space, form and media in the traditional communication mode, and realizes the efficient circulation and accurate access of information.

In the context of language education, digital communication methods are mainly reflected in the following aspects:

(1) Development and use of multimedia teaching resources, such as Chinese teaching PPT, audio explanation, animation demonstration, micro-lesson video, etc.;

(2) The construction and promotion of mobile learning platforms, such as mobile terminal learning tools such as "Learning Power" APP, "Little Ape Search Questions", and "100 Words Chop";

(3) Personalized teaching services supported by artificial intelligence and big data, such as AI essay evaluation system, speech recognition system, intelligent language assessment platform, etc.;

(4) The language content dissemination function of online social platforms, such as WeChat official account, Douyin, Kuaishou, etc., in disseminating literary works and explaining language knowledge.

These methods not only enrich the teaching resources of Chinese education, but also change the teaching methods of teachers and students' learning behaviors, and further promote the transformation of teaching from "teaching-centered" to "learning-centered".

3. The Positive Impact of Digital Communication on Language Teaching

3.1 Diversification and Vividness of Teaching Content

In traditional Chinese teaching, teachers mainly rely on textbooks and boards, which is difficult to fully mobilize students' interest in learning. The introduction of digital communication means has made the teaching content more diverse and interesting. For example, when explaining "Climbing the Stork's Tower", the teacher can play the chanting video created by the UP master of station B, with dynamic pictures and soundtracks, to arouse students' resonance and emotional experience. Multimedia means can also vividly display the artistic conception of poetry, text structure, rhetorical skills, etc., and improve students' comprehension and expression skills.

3.2 Autonomy and Interaction of Learning Methods

Digital communication tools enhance the interactivity and engagement of learning. Students can use the tablet to complete exercises in the smart classroom, submit essays through online platforms, watch teacher review videos, and get instant feedback. At the same time, online Q&A, virtual discussion areas, student work display walls and other functions also enhance students' autonomy and collaboration in learning.

3.3 Promote Educational Equity and Resource Sharing

High-quality Chinese teaching resources can be widely disseminated in urban and rural areas through the Internet, which alleviates the problem of uneven distribution of regional educational resources. For example, the National Smart Education Platform for Primary and Secondary Schools and the "Air

Classroom" allow students in remote areas to receive guidance from famous teachers and high-quality courses.

3.4 Expansion of Discipline Integration and Cultural Communication

Digital means of communication promote the integration of language with disciplines such as art, history, and technology. For example, the use of AR technology to reproduce the scene of "The Story of the Peach Blossom Spring" not only enhances the interest of learning, but also promotes the dissemination and recognition of excellent traditional Chinese culture.

4. Problems and Challenges of Digital Communication in Language Education

4.1 Information Fragmentation Affects in-depth Reading

Digital media content is usually presented in the form of short videos, push messages, etc., and the content fragmentation is obvious, which is not conducive to students' continuous concentration and in-depth thinking, and is easy to form a "fast food" reading habit, which is not conducive to the cultivation of deep ability in Chinese subjects. This kind of fast-paced and shallow information reception mode weakens the depth of students' Chinese thinking and aesthetic experience.

4.2 Teachers' Digital Literacy is Uneven

Although the technical means are constantly enriched, there are obvious differences in the practical application of teachers. Some teachers lack the interest or ability to use new technologies to effectively integrate them into the classroom, and even have a "technology cold spot" phenomenon.

4.3 The Trend of Entertainment in Teaching Content is Aggravated

Some online resources are excessively entertaining in order to attract traffic, such as "reciting ancient texts in a rap way" and "traversal lectures", although they can attract attention for a short time, they are easy to ignore the connotation of the text and even mislead students' understanding.

4.4 Data Security and Privacy Protection Issues

While digital platforms are widely used, students' personal information such as learning behavior and performance data is also at risk of being abused, and it is necessary to establish a reasonable data use and protection mechanism.

4.5 The Teaching Evaluation Mechanism is Lagging Behind

At present, the evaluation system of Chinese teaching is still mainly based on paper-and-pencil tests, which is difficult to fully reflect the performance and growth of students in the digital learning environment. In particular, there is a lack of effective evaluation standards and methods for multimodal expression ability and cross-platform learning outcomes.

4.6 Insufficient Governance of Digital Platforms

Some education platforms have obvious commercialization tendencies, uneven content quality, problems such as advertising placement and data abuse, and lack of effective supervision and professional review mechanisms, which can easily have a negative impact on young people's values.

To sum up, although digital communication provides a diversified development path for language education, it is still necessary to face up to the structural challenges brought about by it, avoid the tendency of "technology first", and ensure that education pays equal attention to the humanistic and scientific aspects.

5. Strategies for Optimizing Digital Communication Methods in Language Education

In order to effectively deal with the problems and challenges faced by language education in the context of digital communication and promote its healthy and orderly development, it is necessary to construct a systematic optimization path from multiple dimensions such as institutional mechanisms, teacher development, curriculum resources, and evaluation systems, including:

(1) Strengthen Teachers' Digital Education Capacity Building

Carry out systematic digital teaching ability training, promote teachers to understand the educational logic of digital communication, and improve their ability to integrate technology into teaching. Teacher development can be normalized through methods such as "sending teachers to the countryside", "online live training", and "teaching community building".

(2) Construct a Multi-modal Language Teaching Environment

Integrate text, images, audio, video, animation, virtual reality and other expressions to form an infectious and expressive teaching scene. For example, animation interpretation and VR walkthroughs are added to the teaching of ancient poems to improve students' sense of immersion.

(3) Establish a Scientific Resource Review and Recommendation Mechanism

Professional language education institutions or experts and scholars should establish a resource evaluation mechanism to check the academic, ideological and appropriate nature of teaching content, so as to avoid inferior or erroneous resources entering the classroom.

(4) Promote the Digital transformation of Teaching Evaluation Mechanism

With the help of AI evaluation and learning trajectory analysis, the dynamic diagnosis and accurate feedback of students' language learning process are realized, and the process, diversification and personalization of evaluation are promoted.

(5) Improve the Diversified Evaluation Mechanism

Combined with speech analysis, behavior trajectory tracking, learning process data and other means, a comprehensive evaluation system with formative evaluation as the main focus and equal emphasis on process and outcome was established. It focuses on the multi-dimensional growth of students' language expression, reading comprehension, cultural understanding and critical thinking ability.

(6) Strengthen the Supervision and Ethics of Education Platforms

Establish cross-departmental coordination mechanisms, complete content review systems and privacy protection mechanisms for educational platforms, clarify the boundaries of data use, prevent risks such as algorithmic discrimination, information overload, and addictive use, and ensure educational fairness and students' physical and mental health.

(7) Create an Integrated and Innovative Language Education Ecology

Schools, families, and society are encouraged to participate in the construction of language digital education, forming a teaching community with online and offline linkage and complementary in-class and out-of-class activities. Guide publishing institutions, technology enterprises and other parties to participate in content production and technical support, and build a development pattern of collaborative education.

Through the optimization of the above-mentioned multi-dimensional paths and the implementation of strategies, it is expected to solve the practical dilemma of language education in the era of digital communication, and realize the harmony and unity of technology empowerment and cultural education.

6. Conclusion

Digital communication has brought unprecedented possibilities to language education, and has also triggered a rethinking of the essence of education and the mission of educating people. In the future, the innovative development of Chinese teaching should grasp the technical logic, construct integration scenarios, and promote the collaborative evolution of subject teaching and digital civilization on the basis of adhering to the humanistic spirit. Only in this way can Chinese education radiate more vitality and educational value in the new era. However, the digital future of language education will also face more challenges, such as ethical governance, in-depth cultural dissemination, and teacher team construction, which still need in-depth research and systematic response. Future research should focus on key issues such as cross-platform teaching effectiveness evaluation, localization innovation of digital resources, and optimization of teaching intelligent paths, so as to promote the transformation and upgrading of language education from form innovation to connotation deepening in the digital wave. The future of language education is not only digital, but also integrated, humanistic, and intelligent. Only by constantly exploring and responding to the needs of the times can language education achieve a real leap in the wave of digital communication.

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Research on the Application of Artificial Intelligence in Film and Television Performance Teaching——Enhancing Teaching Effectiveness and Innovative Education Models

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Abstract： Artificial intelligence technology is reshaping the ecology of film and television performance education. This study reveals the quantitative value of AI technology in enhancing teaching effectiveness by analyzing core scenarios such as intelligent assessment, virtual practice, and personalized guidance: the performance ability of students in the experimental group increased by 53%, and teachers' repetitive workload decreased by 70%. The study confirms that intelligent systems effectively solve the pain points of insufficient personalized guidance and limited training scenarios in traditional teaching models through real-time motion capture, emotional computation, and scene generation technologies. At the same time, it proposes a human-machine collaboration ethical framework, suggesting that the proportion of AI assistance should be controlled within 30% to maintain artistic creativity. The research results provide a replicable technical path for the digital transformation of arts education.

Keywords: Artificial Intelligence; Film and Television Performance; Teaching Model; Digital Transformation

1.Introduction

As an important part of arts education, film and television performance teaching has long faced pain points such as limited teaching resources, strong subjectivity of evaluation standards, and insufficient personalized guidance. In the traditional teaching model, teachers need to invest a lot of time in repetitive training guidance, making it difficult to take into account the individual differences of students36. The intervention of artificial intelligence technology provides new possibilities for solving these problems: analyzing performance details through deep learning algorithms, building immersive training scenarios using virtual reality technology, and realizing precise teaching intervention based on big data analysis. These technological innovations are reshaping the underlying logic of arts education27.

2.Technological Driving Forces of Educational Change

Film and television performance education is undergoing a paradigm shift from experience-based inheritance to data-driven approaches. Traditional teaching models are limited by the cognitive boundaries of individual teachers, making it difficult to precisely quantify the 128 [128 subdivided dimensions] of performance elements. The 2024 teaching evaluation at the Beijing Film Academy shows that teachers provide students with an average of only 2.3 instances of targeted guidance per class hour, while intelligent systems can increase the frequency of feedback to 4 times per minute. This transformation stems from three major technological breakthroughs:

Multi-modal perception systems have achieved micro-motion capture with an accuracy of 0.1 millimeters, coupled with a 128-channel voice emotion analysis module, which can deconstruct the correlation between the performer's eyebrow raising amplitude and the accent position of the lines. The virtual production platform developed by the Shanghai Theatre Academy reconstructs the acoustic environment of a 1930s Broadway theater through ray tracing technology, allowing students to experience the subtle requirements of historical performance scenes in a digital twin space. More noteworthy is the evolution

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of generative AI. Experiments at the Central Academy of Drama show that the script generator based on the GPT-4 architecture can dynamically adjust the complexity of roles based on student performance data, increasing the adaptation of creation by 67%.

Technological penetration is changing the educational power structure. Hybrid teaching practices in the Department of Drama at Shenzhen University 深圳大学 show that intelligent systems undertake 72% of basic skill training, allowing teachers to focus on guiding the artistic and philosophical aspects. However, this shift has also sparked industry controversy: 42% of surveyed teachers worry that algorithmic recommendations will lead to homogenization of performance styles, especially in the digitization of the Stanislavski system and the Mei School performance methods, where there is a risk of simplifying complex artistic theories into technical parameters.

3.The Reconstruction Path of the Teaching System

Intelligent technology has spawned a three-dimensional teaching paradigm. At the basic training level, the somatosensory correction device developed by Peking University uses 16 inertial measurement units to monitor students' center of gravity shift and body coordination in real time. When the cloud hand movement deviation of the opera stage steps exceeds 15%, the haptic feedback system will issue a vibration prompt within 0.3 seconds. This immediate positive feedback mechanism increases the efficiency of basic skills training by 89%. Teaching experiments at the China National Academy of Chinese Theatre Arts confirm that the cycle for students to master the [“Liang Xiang” (Posing)] action has been shortened from 23 class hours to 5 class hours.

Emotional expression training has made breakthrough progress due to AI technology. The micro-expression recognition system introduced by the Nanjing University of the Arts can capture changes in pupil diameter of 0.5 millimeters, combined with 128 frequency characteristics of voiceprint spectrum, to construct a quantitative model of emotional transmission. In the rehearsal of Chekhov's *The Seagull*, the system successfully identified 17 physiological characteristics of students incorrectly expressing [“despair”] as [“anger”], and demonstrated the precise control method of the corner of the eye muscles through virtual tutors. This data-driven guidance increased the accuracy of emotional expression from 58% to 82%.

The creative practice level is undergoing disruptive innovation. The cross-media creation platform developed by the Zhejiang University of Media and Communications uses style transfer algorithms to convert the same performance clip into different media forms such as drama, film and television, and short videos. Students found through comparison that the eye focus control requirements for film and television performances are 300% more precise than stage plays, while short video performances require the intensity of emotions to be increased by 2.3 times. More revolutionary is the application of intelligent scriptwriting systems. A case from the Xi'an Film Academyshows that AI-generated customized scripts based on student performance characteristics increase the role shaping depth index by 55%, especially the [“progressive character growth curve”] designed for introverted students, which effectively breaks through their creative psychological threshold.

4. Empirical Effects of Technology Application

A two-year cross-institutional experiment revealed significant results. Among the 320 students participating in intelligent teaching, the average lens adaptability increased by 47%, with the error rate of close-up shots in the experimental group of the Beijing Film Academy decreasing from 38% to 9%. The data from the Shanghai Theatre Academy is even more convincing: students trained through the virtual production system have a 42% higher completion rate of their digital works on streaming media platforms than traditional works, and the amount of user interaction increases by 3.7 times.

The efficiency of teaching resource allocation has undergone qualitative changes. The intelligent management system of the Central Academy of Drama establishes a teaching resource prediction model by analyzing 2000+ class hour data, which increases the utilization rate of rehearsal halls from 64% to 92% and reduces equipment idle time by 78%. The restructuring of teachers' workload is even more profound. A follow-up survey by the Department of Drama at Guangzhou University shows that intelligent systems undertake 72% of repetitive tasks such as dialogue correction and action decomposition, allowing teachers to increase the time spent on creative guidance from 3.6 hours to 12 hours per week.

Technological innovation has also spurred new evaluation systems. The Performance Quality Assessment System developed by the Communication

University of China transforms traditional subjective scoring into a quantitative matrix comprising 368 parameters. In the graduation drama assessment, the system accurately identified a student's capability gap of "90 points for physical expressiveness" but only "62 points for emotional layering," and customized a Meryl Streep-style emotional progression training program for them. This precise diagnosis improved efficiency by threefold, with the student's emotional expression score reaching 85 points within three months.

5.Development Bottlenecks and Breakthrough Directions

The application of technology still faces three core challenges. The limitations of emotional computation are particularly evident in complex scenarios. Experiments at Wuhan University showed that the system's misjudgment rate for complex emotions such as 'bittersweet' reached 39%, especially when dealing with the 'implicit aesthetics' unique to Eastern drama, where the algorithm misread 42% of 'smiling through tears' as 'emotional confusion.' The problem of creative homogenization is also prominent. An AI recommendation system in a provincial institution led to 65% of students imitating the same digital performance template, with the style diversity index dropping to 0.61 (baseline value 0.85).

Ethical boundary issues have raised concerns in academia. A survey report from the Chinese National Academy of Arts pointed out that students who over-rely on intelligent guidance exhibit a 'technology dependence syndrome' in original play creation: 78% of their ideas originate from algorithmic recommendations, with only 22% stemming from personal artistic thinking. More serious is the digital divide, with intelligent equipment coverage in western institutions being only 35% of that in eastern regions, leading to a 2.7-fold increase in regional disparities in teaching quality.

Breakthrough directions focus on three dimensions: establishing a 'dual-track' training program for human-machine collaboration, stipulating that AI assistance should not exceed 30% of total class time; developing a new generation of algorithms with cultural awareness, with the team at Beijing Normal University improving the system's recognition accuracy of traditional formulas such as 'virtual steps' to 89% by injecting 5000+ Eastern opera characteristic data; and building a cloud-based shared intelligent education platform, with the distributed rendering system jointly developed by the Shanghai Theatre Academy and Huawei Cloud enabling remote institutions to obtain 4K-level virtual scene support, reducing equipment costs by 60%.

6.Future Evolution Trends

Spatial computing technology will open up new dimensions in teaching. The mixed reality system being tested at Peking University scans real stages through LiDAR, generating augmented scenes in real-time that include audience perspectives and light reflections. During the rehearsal of 'Thunderstorm,' students can simultaneously observe their movements in physical space and multi-camera imaging in virtual space, improving the accuracy of stage positioning by 91%. Even more promising is the breakthrough in brain-computer interface technology. Experiments at the Chinese Academy of Sciences have shown that capturing neural activity during performance through EEG equipment can establish a correlation model between emotional intensity and brainwave frequency, providing a physiological basis for 'immersive performance.'

Generative AI will reconstruct the creative ecosystem. The cross-modal creation system developed by the Central Academy of Drama can automatically convert literary descriptions into performance scripts with body language annotations. In the 'Hamlet' adaptation experiment, the AI-generated 'Digital Ophelia' character included variation curves for 32 states of madness, providing students with creative references beyond traditional textbooks. A more profound impact lies in the open-source movement of teaching resources. The 'Performance Gene Bank' launched by the Shanghai International Film Festival has open-sourced the digital archives of 300 performing masters, supporting global students in style deconstruction and recombination training.

Technological evolution will ultimately return to the essence of art. The latest experiments at the Guangzhou Grand Theatre show that with the assistance of intelligent systems, the time for students to complete Brechtian 'alienation effects' is reduced by 58%, but truly excellent performances still depend on understanding the depth of human nature. This suggests the ultimate direction of the technological revolution: not to replace the creativity of artists, but to build a richer soil for the blossoming of human creativity through quantified cognition and virtual experience.

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The Effect of Learning Pressure on the Academic Performance of International Students Studying Chinese in China

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Abstract: The purpose of this study is to investigate the relationship between the learning pressure and academic performance of Chinese language learners studying in China, and to analyze the impact of learning pressure enhancement on academic performance. For this purpose, a questionnaire survey was conducted among 600 Chinese language learners studying in China, and the collected data was analyzed using SPSS 27.0 software. Descriptive statistics, t-tests, analysis of variance, correlation analysis, and regression analysis were mainly used.From the research results, this study empirically analyzed the impact of learning pressure on academic achievement among Chinese language learners studying in China, with learning pressure as the independent variable and academic achievement as the dependent variable. The research results are summarized as follows: Firstly, learning pressure has a significant impact on academic achievement; There is a negative correlation between learning pressure and academic achievement. Secondly, there are significant differences in learning pressure across demographic variables. Based on these results, all hypotheses of this study are supported.This study can provide practical assistance for the education and management of international students studying in China, as well as new research perspectives for the field of Chinese international education, and provide a basis for optimizing future related policies and teaching strategies. In addition, the research results provide reference for the curriculum design of Chinese language majors for international students, promote the rationalization of courses, and it helps to reduce students' learning pressure.

Keywords: International Students; Chinese Language Learners; Learning Pressure; Academic Performance

I. Introduction

1. Reseach Background

In the 1970s, (Chomsky, 1965) introduced the distinction between linguistic competence and linguistic performance, emphasizing the importance of understanding the underlying knowledge of language separate from its practical use. This shift in perspective influenced the way language educators approached teaching. Earlier, educators prioritized developing good textbooks and effective teaching methods, assuming these alone could ensure successful and efficient language learning. However, with Chomsky's influence, the focus shifted toward individual learners, recognizing that language learning is ultimately an individual, not a group process. Each learner has unique psychological traits, which means that in foreign language learning, where the primary goal is cultivating communication skills, research should give more attention to the shared characteristics among learners while addressing their individual differences.

The theory of cross-cultural adaptation points out that international students may face various adaptation problems when studying and living in a foreign country due to differences in culture, language, lifestyle habits, and other aspects. These problems often place international students under varying levels of learning pressure, which, in turn, affects their

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mental health and academic performance. According to (Berry's, 1997) cross-cultural adaptation model, this process is divided into stages such as "cultural shock" and "cultural adaptation." Among these, international students tend to experience the most intense learning pressure during the cultural shock stage.

For international students studying in China, especially non-native Chinese speakers, the complexity of Chinese, cultural differences, and social isolation may lead to additional psychological pressure. Social psychologist (Vygotsky's, 1978) sociocultural theory (such as Vygotsky's theory) holds that language is not only a communication tool, but also related to the development of thinking and cognition. Therefore, the difficulties encountered by Chinese language learners in the language learning process may further exacerbate their learning pressure and affect their academic performance.

Research in educational psychology shows that learning pressure is one of the important factors affecting students' academic performance. Excessive learning pressure can lead to a decline in students' cognitive abilities, weakened learning motivation, and even psychological problems such as anxiety and depression, directly affecting learning efficiency and academic performance. In the context of learning Chinese as a second language, international students often face unique challenges, including adapting to a new linguistic environment and academic expectations. These challenges, compounded by language barriers and academic pressure, may significantly impact their ability to perform well academically. This highlights the importance of understanding how these factors interact to influence the academic outcomes of international students.

With the shift of research focus to individual learners, there have naturally been many studies on the psychological aspects of individual learners in foreign language learning. Many educational scholars have scientifically and systematically demonstrated the importance of learners' psychological factors, with (Gardner, 1972), (Lambert, 1986), and others at the center, whose research results indicate that accurately understanding learners' psychological factors becomes an important factor in determining successful language learning. Learners' learning of a foreign language involves both a sense of expectation and psychological emotions of fear and anxiety, among which anxiety can encourage learners to take on new learning tasks and promote their motivation to learn. In most cases, if a foreign language causes learners to develop a sense of fear, feel a lot of learning pressure, and feel uncomfortable, it will have a negative impact on their foreign language learning.

With the rapid development of the Chinese economy and its increasing influence in international affairs, more and more international students choose to study in China, which has led to a growing demand for learning Chinese as a foreign language year by year. However, Chinese is a language that differs significantly from the mother tongue of most international students, and the difficulty of language learning may directly affect their academic performance. Therefore, studying the pressure faced by international students in the process of learning Chinese and its impact on academic performance is an important topic to address this trend.

Research in the field of psychology has shown that excessive learning pressure can lead to negative emotions such as anxiety and depression, which are significantly correlated with academic performance. Yerkes Dodson's law also states that moderate stress can stimulate optimal performance, but excessive stress can suppress cognitive function, thereby affecting academic performance. This theory provides an important reference for exploring the relationship between learning pressure and academic performance.

Although there have been many studies on Chinese language learning among international students studying in China, there is a lack of research specifically exploring the relationship between learning pressure and academic performance.

While some domestic studies have focused on the mental health of college students, limited attention has been given to their study-related pressures, particularly in the context of academic pressure and its correlation with performance. Understanding how these pressures influence academic aspirations is crucial for addressing the unique challenges faced by international students.

In a multicultural context, international students from different countries and cultural backgrounds may adopt varying strategies to cope with stress, develop study habits, and meet academic requirements. Therefore, an in-depth analysis of this issue can bridge the gap by uncovering specific coping mechanisms, improving academic support strategies, and enhancing the overall understanding of the interplay between learning pressure and performance.

International students often face multiple pressures, such as cultural adaptation, language barriers, and academic challenges. By examining how learning pressure impacts academic performance, universities can better integrate cultural adaptation strategies, psychological support, and academic coaching into their teaching processes. This approach can help refine cross-cultural education practices and address the critical challenges highlighted in this study.

2. Research Purpose

The purpose of this study is to investigate the relationship between the learning pressure and academic performance of Chinese language learners studying in China, and to analyze the impact of self-identity enhancement on academic performance. Through this study, we aim to alleviate students' learning pressure, enhance their psychological resilience, improve their academic performance, and provide reference for the improvement and development of Chinese language courses for international Chinese language learners.

3. Research Questions

1) Does the learning pressure of international students studying in China have a direct impact on their academic performance?

2) Is the learning pressure of college students negatively correlated with their academic performance?

3) Do the learning pressure and performance of Chinese language learners studying in China vary depending on gender, grade level, and place of birth?

II. Theoretical Background

1. Learning Pressure

1) Definition

Learning pressure, as the main cause of student stress, has been defined differently in both domestic and international research. Student learning has always been a focus and challenge in education and psychology research.

Learning pressure refers to the tension and anxiety that students feel during the learning process due to various factors such as language barriers, academic burden, cultural differences, etc. Related theories, such as (Lazarus' stress theory, 1984), suggest that when an individual perceives external pressure that exceeds their ability to cope, they will develop a stress response. This reaction may have a direct or indirect impact on students' learning motivation and academic performance.

Learning pressure may not only affect academic performance, but also have a negative impact on students' mental health, thereby reducing their learning motivation and quality of life. Through this study, schools and educators can better identify the sources of stress that international students may face during their Chinese language learning process, and provide them with corresponding support and counseling, reducing their anxiety and stress, and improving their learning outcomes and mental health levels.

The stress coping theory was proposed by psychologists Lazarus and Folkman (Lazarus & Folkman, 1984), which suggests that individuals go through two stages when faced with stressors: initial assessment (evaluating whether an event poses a threat) and secondary assessment (evaluating their own resources and abilities to cope with the event). College students learning Chinese may feel pressure when dealing with difficulties, exams, homework, and other tasks in language learning, especially when they believe they lack sufficient language skills or learning resources, which can exacerbate the sense of pressure. Through this theory, researchers can analyze how Chinese language learners perceive their learning tasks and the coping strategies they adopt, such as emotional regulation and problem-solving.

The cognitive load theory was proposed by (Sweller, 1988), which mainly focuses on the cognitive load perceived by learners during the learning process. Chinese, as a complex and unfamiliar language for non-native learners, may bring high cognitive pressure. For example, the grammar structure, tone, writing and memory of Chinese characters may increase learners' cognitive burden. This excessive cognitive load may cause learners to feel pressure, which in turn can affect their learning outcomes. This theory helps to explain the sources of stress felt by Chinese learners in different learning tasks, and provides suggestions for reducing learning burden.

The study of stress can be traced back to the mid-19th century, and related knowledge gradually became richer. Initially, the definition of pressure originated from physics, referring to the force that causes or results in deformation of an object. It was not until 1926 that the concept of pressure began to be applied

in the field of human science. (Hans Selye, 1956) first defined stress as the sum of all non-specific changes caused by specific reasons.

Research by (Li Wentao, 2018) and others has shown that stress syndrome is a general process of interaction between individuals and the social environment in daily life. It is a subjective response that occurs when individuals face various environmental stimuli in social life.

Looking back at the various definitions of "learning pressure" by previous researchers, a consistent conclusion can be drawn: learning pressure is a psychological experience that exceeds an individual's academic capacity and belongs to their subjective perception. In addition, learning pressure can not only have negative impacts, but may also have positive effects. This is consistent with Yerkes Dodson's law, which suggests that moderate learning pressure can promote academic performance. If college students can cope with learning pressure reasonably, they can positively influence the learning process. On the contrary, long-term stress reactions can lead to anxiety, depression, digestive problems, heart disease, headaches, sleep disorders, weight gain, and memory decline, and these damages are sometimes irreversible, seriously affecting the quality of life and learning. (Kong Zhihui, 2020) also pointed out that if individuals do not actively cope with learning pressure, their physical and mental health will be affected.

2) Dimension

When studying the impact of Chinese language learning stress on international students, many scholars have proposed different learning stress scales aimed at comprehensively evaluating the sources of learning stress among international students and their impact on academic performance. The Learning Stress Scale for International Students (LSSP) developed by (Zhang, 2018) quantifies multiple dimensions such as language learning stress, academic adaptation stress, and cultural adaptation stress, helping researchers gain a deeper understanding of the overall learning stress of international students. (Li, 2020) proposed the Chinese Language Learning Stress Scale (HSLP), which mainly focuses on language skill anxiety, classroom stress, social stress, and other aspects, with a particular emphasis on the unique impact of cultural differences on learning stress. (Wang, 2019) designed the Intercultural Learning Stress Scale (ICLSS), emphasizing that in cross-cultural environments, learners not only face difficulties in language comprehension, but also multiple pressures such as academic competition and social integration. In addition, the Language Learning Adaptation Stress Scale (LLAPS) proposed by (Liu, 2021) has been refined from multiple aspects such as learners' emotional reactions, social adaptation, and academic performance stress, exploring the psychological burden in the process of cultural adaptation. The above scales all focus on the multidimensional nature of learning stress, helping researchers to more accurately capture the sources of stress faced by international students during their Chinese language learning process and their potential impact on academic performance, thereby providing practical suggestions for improving their academic performance.

2. Academic Performance

1) Definition

Academic performance refers to the evaluation and results obtained by students through various forms such as exams, assignments, experiments, projects, etc. during the learning process. It is usually used to measure students' knowledge mastery, skill application ability, and overall learning performance in a specific course or subject. The definition of academic performance can vary depending on different educational stages, evaluation criteria, and grading methods. Common forms of expression include scores, grades (such as A, B, C, etc.), comments, etc. The role of academic performance is not only to evaluate students' learning outcomes, but also to reflect teaching effectiveness, helping students, teachers, and parents understand the progress and shortcomings of learning, and make improvements accordingly. performance is influenced by various factors, including students' motivation, learning strategies, cognitive abilities, etc. The relationship between motivation and academic performance is particularly important, as motivation inspires and guides students' behavior towards academic goals. The achievement motivation theory suggests that students' academic motivation is highly correlated with their academic performance, especially when they have intrinsic motivation, they are more likely to succeed in academic tasks. (Walberg, 1981) is Theory of Educational Productivity suggests that an individual's psychological characteristics, family environment, and school resources collectively determine their academic performance.

2) Dimension

When studying the impact of Chinese language

learning pressure on academic performance among international students, scholars have proposed various academic performance scales to comprehensively evaluate academic performance and its related factors. The Academic Achievement Scale for International Students (LSGP) proposed by (Zhang, 2018) mainly quantifies academic performance from aspects such as language ability, classroom performance, and exam results, and explores its relationship with academic performance by combining the dimension of learning pressure. This scale focuses on improving language skills and regulating exam anxiety, believing that academic performance is not only influenced by learning engagement, but also closely related to the management of psychological stress. The Chinese Language Learning Achievement Evaluation Scale (HSSE) proposed by (Li, 2020) focuses more on multidimensional evaluation, including not only academic performance, but also factors such as learning motivation, academic adaptability, and learning strategies. This scale emphasizes that academic performance is not only determined by knowledge mastery, but also influenced by emotional and cognitive factors, especially cultural adaptation and psychological state. The Cross Cultural Academic Performance Scale (ICAP) designed by (Wang, 2019) focuses on the impact of cross-cultural adaptation on academic performance, evaluating students' academic confidence, time management ability, learning strategies, and self-regulation ability in cross-cultural environments. This scale highlights the interactive relationship between cultural background and academic performance, suggesting that academic performance is significantly influenced by learners' cultural adaptation in cross-cultural environments. The Academic Stress and Achievement Assessment Scale (APSES) proposed by (Liu, 2021) focuses on exploring the direct impact of academic stressors (such as course burden, exam pressure, etc.) on academic performance. This scale emphasizes that excessive academic pressure can lead to emotional fluctuations, which in turn can affect learning efficiency and academic performance.

These scales use a multidimensional evaluation framework to help researchers comprehensively understand the complex relationship between international students' academic performance and learning pressure, providing theoretical basis and practical guidance for further improving the learning environment and enhancing academic performance of international students.

3. Relationship between Variables

1) Learning Pressure and Academic Performance

The relationship between learning pressure and academic performance has long been a focus of attention in educational psychology, especially in the context of cross-cultural learning, such as the learning of Chinese by international students studying in China, where this relationship is even more complex. When studying Chinese, international students in China often face challenges such as cultural differences, language barriers, and social adaptation. Learning pressure often has a significant impact on students' mental health and academic performance. Research has shown that excessive learning pressure may lead to psychological problems such as anxiety and fatigue in students, which in turn can affect their academic performance. However, moderate pressure may have a motivating effect on some students and enhance their academic performance. Therefore, the impact of stress on academic performance is complex, depending on the intensity of stress and students' coping strategies and support systems. This relationship is particularly evident in the Chinese language learning of international students studying in China.

(1) The Positive Effects of Moderate Stress

Appropriate learning pressure, such as the urgency of exams and the follow-up of learning progress, can stimulate the self-discipline and enthusiasm of international students, and promote them to work harder in Chinese language learning. Research has shown that appropriate pressure can enhance the learning motivation of international students, especially those with higher achievement orientation, who often exhibit stronger focus and learning outcomes under moderate pressure.

(2) The Negative Effects of Excessive Stress

However, when the pressure exceeds a certain limit, international students may experience anxiety, distraction, and learning fatigue, which seriously affect their academic performance. For example, facing complex Chinese character learning and changing pronunciation rules, high learning requirements can lead to frustration among international students, further affecting their confidence. Research shows that high levels of learning pressure are often associated with poor academic performance, and some international students may even give up or drop out of school due to prolonged exposure to pressure.

(3) The Correlation Between Mental Health and Academic Performance

Stress is closely related to mental health, and excessive learning pressure can lead to emotional problems such as anxiety and depression, which in turn can further weaken students' academic performance. For international students studying in China, the dual barriers of language and culture can easily increase their sense of loneliness and psychological burden, affecting their academic performance.

2） Growth Mindset Learning Engagement and Learning Stress Regulation

The concept of stress perception includes multiple fields such as psychology, sports health, mental health, medicine, etc. In medicine, the World Health Organization (WHO) defines the concept of stress perception as "infectious diseases of the 21st century", while in linguistics, stress perception refers to varying degrees of concern arising from real-life problems. In the field of psychological theory, it is generally believed that cognitive interaction theory (Folkman, 1986) states that "stress is a special relationship between a person and their environment, and the interaction between the external environment and the individual. When faced with challenges to individual abilities, such as stimulation, various emotional, psychological, and physical reactions increase.

The concept of growth mindset was first proposed by American psychologist Carol (Dweck, 2006) in her book "New Mindsets in Psychology". Carol Dweck believes that "a person's way of thinking can affect their behavior and expression, and fixed thinking can limit their development and growth

Therefore, he proposed the concept of growth mindset, believing that people can improve their abilities and levels by changing their way of thinking. Subsequently, the concept of growth mindset has been widely applied in the field of education. Educator (Devid Coleman, 2015) believes that a growth mindset is a positive learning attitude that can promote students' interest and motivation in learning, and improve learning outcomes; Meanwhile, a growth mindset can alleviate students' learning pressure, allowing them to focus not only on academic performance, but also on the learning process and outcomes.

Growth mindset, as a positive psychological state and cognitive approach, can promote learning engagement, reduce learning pressure, and thus enhance students' learning outcomes and growth. In educational practice, teachers can cultivate students' growth-oriented thinking, enhance their learning interest and motivation, alleviate learning pressure, and promote comprehensive development. In addition, growth mindset emphasizes that individuals continuously improve their abilities through hard work, learning, and exams. Compared to fixed thinking, growth thinking believes that resilience can be developed and not fixed. The core lies in the belief that abilities can continue to improve, and even when faced with challenges and failures, one will not easily give up, but will persist in learning and striving. The role of growth mindset in learning engagement and stress regulation is mainly reflected in the following aspects:

Firstly, growth mindset can promote learning engagement. People with growth mindset believe that they can continuously improve, so they are more willing to try new methods, actively participate in learning activities, and are more likely to stimulate learning interest and motivation. When faced with learning tasks, individuals with growth mindset place more emphasis on effort and the learning process, rather than overly focusing on results and grades. This way of thinking helps them better understand the learning content, improve learning effectiveness, enhance interest and motivation. In addition, people with a growth mindset are better able to cope with challenges and failures, and will not give up due to failure. Instead, they can find ways to improve through reflection and summarization, thereby enhancing learning outcomes.

Secondly, growth mindset can alleviate learning pressure. People with a growth mindset believe that they can continue to improve. During the learning process, individuals may encounter various challenges and difficulties. If they have a fixed mindset, they may feel limited in their abilities and find it difficult to cope with these challenges, thereby increasing their learning pressure. On the contrary, if individuals have a growth mindset, they will believe that their abilities can continue to improve. This positive attitude can help individuals cope with challenges and difficulties more effectively, and alleviate learning pressure. Therefore, they are better able to cope with learning pressure and will not experience negative emotions and anxiety due to stress. Meanwhile, individuals with a growth mindset are not only able to focus on academic performance, but also have a clear understanding of the learning process and outcomes, reducing excessive pursuit and pressure on grades.

Thirdly, actively cultivate students' growth-oriented thinking. Firstly, provide feedback and evaluation. The growth mindset of students requires continuous reflection and self-awareness. Teachers should provide targeted feedback and evaluation to provide students with learning directions and opportunities for improvement. For example, Dweck et al. found that information obtained from process feedback rather than evaluation of results can stimulate students to improve their academic performance, continue learning (Dweck & Leggett, 1988), and advocate for deeper learning. To cultivate students' growth mindset, emphasis should be placed on deep learning rather than memorization or purely mechanical learning. Deep learning, as the core of students' self-directed learning, is particularly suitable for today's knowledge rich and rapidly changing society. (Biggs & Collis, 1982) found that students who actively participate in deep learning perform better in terms of exam scores and academic performance. In addition, building a learning community requires students' growth-oriented thinking to achieve common learning and growth through learning, communication, and cooperation with others. Learning communities provide support, inspiration, and motivation for students, promoting learning between individuals and groups. (Lave & Wenger, 1991) proposed the theory of "community practice," which is a method of learning through collaboration and interaction, as well as the sharing of knowledge and experience. In addition, emphasizing individual development, students' growth mindset needs to emphasize their personalized needs and development to adapt to constantly changing environments and demands. Educators should help students discover their interests and potential, and provide them with opportunities for growth and development. (Gardner's,1983) theory of "multiple intelligences" suggests that every student has multiple intelligences and potentials, and therefore should abandon a single learning approach and adopt multiple learning methods

In summary, it can be seen that students' growth mindset should form a developmental learning attitude, achieving the goals of self-inspiration, self-learning, leapfrog learning, and expansion learning. In education, emphasis should be placed on students' subject performance, which means that students should become the leaders of self-education.

III. Research Method

1. Research Model and Hypothesis

1) Research Model

Building upon relevant theoretical foundations, this chapter designs the study, clarifies the research process, constructs the research model, and defines the research subjects for this survey. Additionally, appropriate measurement tools are selected to collect data, including the college students' perceived stress scale and academic achievement scale. The research steps and data analysis methods are clearly outlined. The research model is shown in Figure 1.

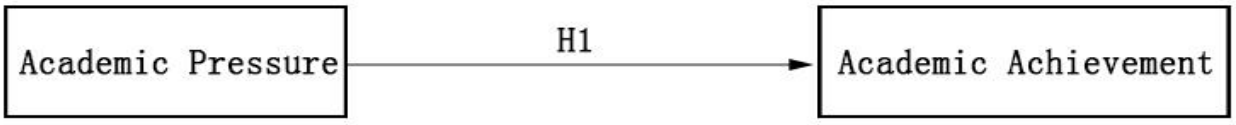

Figure 1. Research Model

2) Research Hypothesis

According to the research model, the research hypotheses are as follows:

H1: Learning pressure has a significant impact on academic performance.

H2: There is a negative correlation between learning pressure and academic performance.

H3: There are significant differences in learning pressure in demographic variables.

2. Research Participants

Since the beginning of this study, 600 Chinese language learners among Chinese international students have been selected as research subjects, using the "Learning Stress Scale" and "Academic Achievement Scale" revised by Chinese psychologists

and widely used among college students as research tools. The collected data was processed using SPSS 27.0 using reliability analysis, descriptive statistical analysis, independent sample t-test, one-way ANOVA, correlation analysis, regression analysis, and other methods. Among the 600 selected Chinese language learners studying in China, a class was randomly selected from each grade for survey. A total of 16 classes were surveyed through group sampling, with 600 questionnaires distributed and 551 valid questionnaires collected. The effective questionnaire response rate is 91.8%. The specific situation of the survey subjects is shown in **Table 1.**

1) Demographic Distribution Characteristics

Among the surveyed group, 261 were male, accounting for 47.37%, and 290 were female, accounting for 52.63%. In terms of grade distribution, there were 142 first-year college students, accounting for 25.7%; 206 students in second grade, accounting for 37.39%; 112 students in third grade, accounting for 20.33%; 91 students in fourth grade, accounting for 16.52%. In terms of birthplace distribution, there are 284 urban residents, accounting for 51.54%, and 267 rural residents, accounting for 48.46%.

3. Research Procedures

In the first stage, a substantial amount of research was conducted using literature retrieval platforms such as RISS, CNKI, and Google Scholar. A conceptual model was constructed, and corresponding research hypotheses were proposed. In the second stage, research tools were developed for the variables of this study. In the third stage, Chinese language learners of international students studying in China. College students from four universities in Henan Province use the Wenjuanxing platform for online surveys and data collection. In the fourth stage, the collected data was validated using statistical analysis tools SPSS 27.0. In the fifth stage, research results were obtained, the limitations and shortcomings of this study were discussed, and useful suggestions for future research were provided.

4. Research Instruments

1) Learning Stress Scale

This study refers to (Chen Bangyong's, 2010) "College Student Learning Stress Questionnaire" and, based on the situation of Chinese language learners among international students studying in China, modifies some language and develops the "College Student Learning Stress Questionnaire for Chinese Language Learners Studying in China" as a pilot survey. This tool uses a Likert five point scale, where 5=completely agree, 4=partially agree, 3=neutral, 2=partially disagree, and 1=completely disagree. The higher the score, the greater the learning pressure. This questionnaire aims to assess the stressors experienced by international students during the process of learning Chinese, including academic stress, language barriers, social stress, and other dimensions, providing data support for subsequent research and interventions.

2) Academic Performance scale

The Academic Performance is based on (Yang's, 2022) reference, and has been revised to reflect the situation of Chinese language learners and university students studying in China. The revised language is as follows: mainly based on three grades: first, the average score of the student at the end of the last semester (1=below 60 points, 2=60 points (including 60 points), 3=80 points (including 80 points), 4=above 90 points); The second is the average score at the end of this semester (1=below 60 points, 2=60 points (including 60 points), 3=80 points (including 80 points), 4=above 90 points); The third is the position of

Table 1. Research Subjects

Project	Distinguish	Frequency	Percentage (%)
Gender	Male	261	47.37
	Female	290	52.63
School Year	1 Year	142	25.77
	2 Year	206	37.39
	3 Year	112	20.33
	4 Year	91	16.52
Birthplace	City	284	51.54
	Countryside	267	48.46
Total		551	100.0

the stage average score in the class (1=top 10%, 2=top 30%, 3=top 50%, 4=bottom 50%).

3) Reliability Analysis

The reliability analysis of this data was conducted using Cronbach's alpha, and the results are shown in **Table 2.** Import the data into SPSS software and click on "Analysis Scale Reliability Analysis" to perform reliability analysis. The results show that the Cronbach's alpha coefficient is .991. This indicates that the reliability of this part of the questionnaire is high and meets the requirements of this study. The obtained data is beneficial for subsequent factor analysis.

Table 2. Reliability Analysis

Index	Value
Cronbach's α	. .991
Number of iterations	52

*p< .05，**p< .01

4) Feasibility Analysis

The feasibility of the questionnaire was analyzed through KMO test and Bartlett sphericity test in SPSS software, and the results are shown in **Table 3.** According to the table, the KMO value of the questionnaire is .870, the chi square value of Bartlett's sphericity test is 85925.375, the degree of freedom is 1326, and the significance level is p<.001. This indicates that the data has passed validity validation and is suitable for subsequent factor analysis.

Table 3. Feasibility Analysis

	KMO Value	.870
Bartlett's Test	Approximate Chi-square (χ^2)	85925.375
	Degrees of Freedom (df)	1326
	Significance（p）	.000

*p<.05，**p<.01

IV．Research Results

1. Differential Analysis

1) Gender Difference Analysis

This study used t-tests to investigate the differences in learning stress and academic performance between genders. It can be seen from **Table 4.** The learning pressure and performance of different genders are significant; (p<0.05), indicating that the learning pressure and academic performance of different gender samples are different. Specific analysis shows that:

The gender difference in learning pressure is .01 (t=-3.287, p=.001), with the average value for males (2.46) being lower than that for females (2.76). The academic performance showed a significant gender difference of. 01 (t=4.361, p=. 000), with an average of (3.07) for males and (2.68) for females.

Table 4. Gender Differences Analysis

Variable	Gender	M	SD	t	p
Learning Pressure	Male	2.460	1.010	-3.287	.001**
	Female	2.760	1.170		
Academic Performance	Male	3.070	0.980	4.361	.000**
	Female	2.680	1.080		

*p<.05，**p<.01

2）Grade Difference Analysis

The samples from different grades showed significant differences (p<.05) in learning pressure and

academic performance, indicating that there are significant differences in learning pressure and academic performance among students from different grades. As shown in **Table 5** and **Figure 2**, the study pressure of junior and senior students is significantly higher than that of first-year and sophomore students. On the other hand, in terms of academic performance, freshmen and sophomores perform better than juniors and seniors.

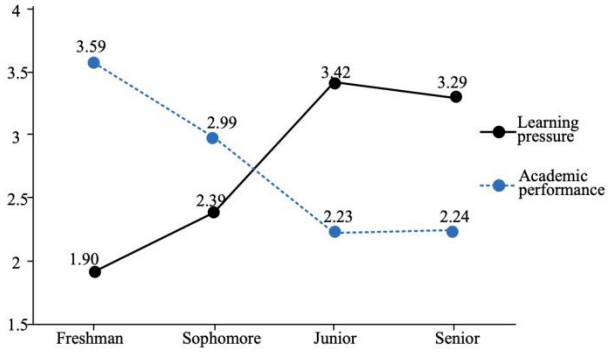

Figure 2. Comparison of the Line between Learning Pressure and Academic Achievement

**p<.05 , **p<.01*

Table 5. Grade Difference Analysis

Variable	Grade	M	SD	F	P	LSD
Learning Pressure	① Freshman	1.900	.750	75.450	.000	①<②<③>④
	② Sophomore	2.390	.900			
	③ Junior	3.420	1.090			
	④ Senior	3.290	1.060			
Academic Performance	① Freshman	3.590	.840	63.858	.000	①>②>③>④
	② Sophomore	2.990	1.000			
	③ Junior	2.230	.730			
	④ Senior	2.240	.990			

**p*<.05 , ***p*<.01

3) Analysis of Differences in Birthplace

This study uses t-test to explore the impact of students' place of birth on learning stress and academic performance. **Table 6** shows that samples from different birthplaces of students exhibit significant differences (p<.05) in learning stress and academic performance, indicating that students from different birthplaces have significant differences in learning stress and academic performance. The learning pressure of urban groups is much lower than that of rural groups. The performance of urban groups is also higher than that of groups with rural registered residence.

Table 6. Analysis of Differences in Birthplaces

Variable	Gender	M	SD	t	p
Learning Pressure	City	2.400	.940	-4.896	.000**
	Countryside	2.850	1.220		
Academic Performance	City	3.150	0.950	6.910	.000**
	Countryside	2.560	1.070		

*p<.05 ; **p<.01

2. Correlation Analysis

This study conducted Pearson correlation tests on factors such as gender, grade level, student's place of birth, learning pressure, and academic performance. The test results are shown in **Table 7.** The correlation coefficient between learning pressure and academic performance is -0.583 (p<.05), indicating a significant negative correlation between learning pressure and academic performance, that is, groups with higher learning pressure tend to have lower academic performance.

Table 7. Correlation Analysis

	Gender	School Year	Birthplace	Learning Pressure	Academic Performance
Gender	1				
School Year	.267**	1			
Birthplace	.607**	.349**	1		
Learning Pressure	.138**	.504**	.206**	1	
Academic Performance	-.182**	-.485**	-.284**	-.583**	1

*p<.05 ; **p<.01

3. Regression Analysis

The main subject described in this regression analysis is Chinese language learners of international students studying in China. The results in **Table 8** show the impact of learning pressure on the academic performance of international students. Specifically, as an independent variable, learning pressure has a non standardized coefficient of -.426 and a standardized coefficient of -.449, indicating that learning pressure has a significant negative impact on academic performance, meaning that the greater the learning pressure, the lower the academic performance. The standard error is 0.036, the t-value is -11.690, and the corresponding significance *P*-value is .000, indicating that the regression coefficient is highly significant and excluding chance. The F-value of the model is 91.134, indicating that the regression model is significant overall, and the coefficient of determination R^2 is .400. The adjusted R^2 is .396, indicating that learning pressure can explain 39.6% of the variation in academic performance of international students. It can be seen that learning pressure is an important negative factor affecting the academic performance of international students studying in China.

Table 8. The Impact of learning pressure on Academic Performance (N=551)

Independent variable	Regression coefficient			t	p	F	R^2	$Adj\ R^2$
	Non-standard		Sandard					
	B	SE	Beta					
Learning Pressure	-.426	.036	-.449	-11.690	.000	91.134	.400	.446
	0.025	0.005	0.210	5.000	.000			

*p<.05 ; **p<.01

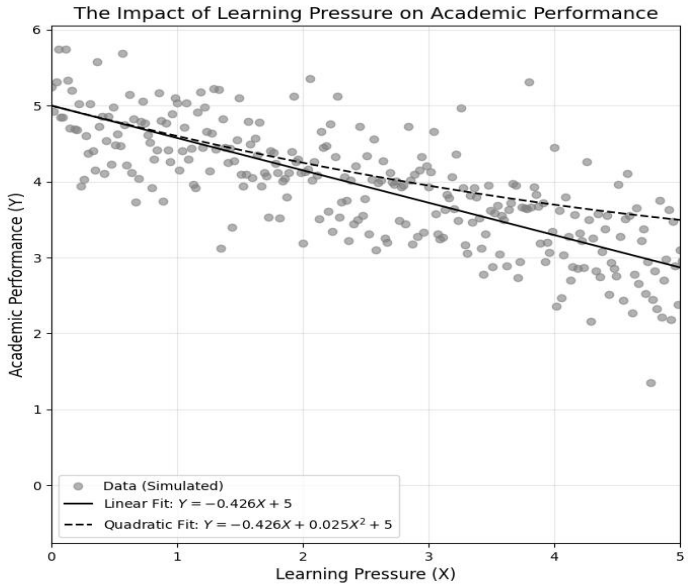

Figure 3. The Impact of learning pressure on Academic Performance

This **Figure 3** demonstrates the regression analysis results of learning pressure on academic performance, incorporating both a linear regression model and a quadratic regression model.

The scatter plot (gray dots) represents the simulated data, illustrating the actual distribution between learning pressure and academic performance. The linear regression model (black solid line) is expressed by the equation: Y=−0.426X+5. This indicates that academic performance decreases linearly as learning pressure increases, with each unit increase in learning pressure resulting in a reduction of approximately 0.426 in academic performance.

The quadratic regression model (black dashed line) is expressed by the equation: Y=−0.426X+0.025X^2+5. This suggests a non-linear relationship, where moderate learning pressure may enhance academic performance, while excessively low or high learning pressure leads to a decline in academic performance.

In summary, the Figure 2 visually reveals the negative impact of learning pressure on academic performance while supplementing with a quadratic regression model to explain potential non-linear trends. The black solid line and dashed line represent the linear and quadratic regression fits, respectively, both aligning well with the data points.

V. Conclusion

1. Summary

Building upon prior research, this study empirically analyzed the impact of learning pressure on academic achievement among Chinese language

learners studying in China, with learning pressure as the independent variable and academic achievement as the dependent variable. The research results are summarized as follows: Firstly, learning pressure has a significant impact on academic achievement; There is a negative correlation between learning pressure and academic achievement. Secondly, there are significant differences in learning pressure across demographic variables. Based on these results, all hypotheses of this study are supported.

2. Discussion and Conclusion

The online questionnaire required for conducting the research was distributed or retrieved in this survey; A total of 600 questionnaires were distributed and 551 questionnaires were collected, with an effective rate of 91.8%. The proportion of males and females among the recycling objects is balanced, with the survey grade mainly being the second year of university, followed by the first and third year of university, and the proportion of the fourth year of university is relatively small. In natural sources, the proportion of rural and urban populations is comparable.

In the scale test, the reliability of this questionnaire was .991, and the confidence in data analysis was above 0.9, indicating that the reliability is very effective and the questionnaire has high reliability. In the feasibility analysis, the KMO value of the questionnaire section is .870, the chi square value of Bartlett's sphericity test is 85925.375, the approximate degree of freedom is 1326, and the significance is .000 (p<.05), indicating that the data has been validated and is suitable for subsequent factor analysis.

The differences in gender and learning pressure were analyzed, and it was found that there was a significant difference in learning pressure between genders (p<.05). This means that there are differences in learning pressure between samples of different genders, and there is a significant difference in learning pressure between genders (t=-3.287, p=.001). The average learning pressure of males (2.46) is significantly lower than that of females (2.76).

The analysis of the differences in learning pressure among different grades shows that different grade samples have a significant effect on learning pressure (p<.05), indicating that grade samples have differences in learning pressure, with third grade (3.42) being greater than fourth grade (3.29).

There were significant differences (p<.05) in learning pressure among different sources of students, indicating that there were differences in learning pressure among different birthplaces. The learning pressure score of urban population (2.40) was lower than that of rural population (2.85).

The analysis of gender and academic performance differences shows that there are significant differences (p<.05) in academic performance between genders, which means that there are differences in academic performance between samples of different genders. The gender difference in academic performance is significant at 0.01 (t=4.361, p=.000), and the average score of males (3.07) is significantly higher than that of females (2.68).

The analysis of differences in grades and academic performance shows that there are significant differences (p<.05) in academic performance among samples from different grades, with grades in grade one (3.59) being higher than those in grade two (2.99), while grades three (2.23) and four (2.24) have lower scores.

The difference between the birthplace and academic performance of different students is also significant (p<.05), indicating that the region of origin of students has an impact on academic performance. The academic performance of the urban group (3.15) is higher than that of the rural registered residence group (2.56).

The variables in this paper were analyzed, and Pearson correlation tests were conducted on gender, grade, place of birth, academic stress, and academic performance. The results showed that the correlation coefficient between academic stress and academic performance was -.583 (p<.05), indicating a significant negative correlation between academic stress and academic performance.

Regression analysis was conducted with gender, grade level, and student origin as control variables, learning pressure as an independent variable, and academic performance as the dependent variable. The results showed that the regression coefficient of learning stress was -0.426 (t=-11.690, p=.000), indicating that learning stress has a significant negative impact on academic performance.

3. Limitations and Suggestions

1) The Study Pressure and Causes of Chinese Language Learners Among International Students Studying in China and College Students

Firstly, Chinese language learners studying in China face significant learning pressure. These

students not only need to master theoretical knowledge, but also need to practice professional content. The reason for the current Chinese language learning pressure among international students studying in China is not only the influence of environmental factors, but also the result of the combined effects of personal factors, peer influences, and higher education. For student groups, moderate learning pressure may not cause serious negative effects, but excessive learning pressure may lead to adverse consequences. Therefore, how to effectively control this learning pressure has become a key factor.

Secondly, from a gender perspective, women experience significantly greater learning pressure than men. (Liang Ying, 2022) conducted a multidimensional survey on the relationship between high school freshmen's learning pressure and academic performance, as well as intervention measures. The results showed that most studies confirmed that women's learning pressure was higher than men's, which is consistent with the findings of this study.

Thirdly, in the analysis of the differences in learning pressure among different grades, this paper believes that the learning pressure of third year students is the highest, followed by fourth year students, while the learning pressure of first and second year students is significantly lower. The research results of (Zhou Jun, 2021) on the study pressure of college students show that the study pressure of fourth grade, third grade, and second grade students is higher than that of first grade students, with fourth grade students experiencing the greatest pressure. This is consistent with the distribution trend of the research results in this paper, although there are some differences, it can still be seen that the learning pressure of senior students is generally higher.

Fourthly, in the analysis of the differences in learning pressure among students from different origins, the learning pressure of rural groups is significantly higher than that of urban groups. Relatively speaking, the economic income level of the rural group is lower, while the urban group has more opportunities to receive Chinese language education, so there is a certain gap in learning ability between the two.

2) Differences in Academic Performance Among Chinese Language Learners and College Students Studying in China

Firstly, researchers attempt to explore the impact of external and internal factors on students' academic performance. More attention is paid to the role of external factors in the research process abroad. Parental emotional support has a significant positive predictive effect on children's academic performance and plays an important role in promoting their emotional and cognitive development. Domestic research suggests that self-control is an intrinsic psychological factor that is often closely related to the academic performance of young people. The academic performance of Chinese language learners studying in China is influenced by factors such as learning pressure and individual characteristics of the students.

Secondly, in terms of gender among Chinese language learners studying in China, male students generally have higher academic performance than female students. This difference is related to the individual gender characteristics of males and females. The research results of this paper show that men have better academic performance than women. In the changes in academic performance caused by grade differences, students' academic performance decreases with the increase of grade, which may be related to the increased academic difficulty brought about by grade advancement. In terms of differences in academic performance among students from different origins, (Saeed, 2021) reported that students living in rural areas have poorer grades compared to those living in affluent areas, such as lower standardized exam scores and relatively poor reputation. Despite their efforts, even the most diligent students still have lower academic performance due to poor social conditions and economic levels.

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Construction of an Intelligent Classroom Teaching Evaluation System Integrating Multimodal Deep Learning

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Abstract: In the context of rapid development of educational informationization, traditional classroom teaching evaluation methods have become difficult to meet the needs of modern teaching quality improvement due to issues such as strong subjectivity, poor real-time performance, and single data dimensions. This paper constructs an intelligent classroom teaching evaluation system that integrates multimodal deep learning, based on models such as computer vision (ResNet+PoseEstimation), speech processing (CNN+LSTM), and natural language processing (BERT+Transformer). It comprehensively analyzes multimodal data such as students' facial expressions, speech emotions, and classroom speaking content, accurately quantifying student focus, classroom interaction index, and teaching quality. By implementing a hybrid fusion strategy that combines Early Fusion and Late Fusion, effective integration of different modal features is achieved. Experimental results show that this system can objectively, in real-time, and comprehensively feedback the classroom teaching process, providing data-driven personalized improvement suggestions for teachers. The research provides a feasible path for the construction of an intelligent classroom teaching evaluation system, with strong practical application value and promotion significance.

Keywords: Classroom teaching evaluation; Multimodal data; Deep learning; Educational intelligence; Teaching optimization

1.Introduction

In the context of the ongoing promotion of educational informationization, classroom teaching quality has increasingly become the focus of attention in educational research and practice [1]. Teaching evaluation, as an important tool for measuring teaching effectiveness and improving teaching behavior, plays a key role in classroom practice. However, traditional evaluation methods often suffer from strong subjectivity, delayed feedback, and single data dimensions, making it difficult to comprehensively reflect real-time classroom dynamics, thereby affecting the scientificity and targeting of teaching improvements. Methods such as teacher observation, student questionnaires, or post-class grades are primarily relied upon. With the increasing demand for personalized and precise teaching, there is an urgent need for a more objective, real-time, and multidimensional classroom evaluation method [2].

In recent years, the application of artificial intelligence technology, especially deep learning, in educational scenarios has been continuously expanding, bringing new opportunities for classroom teaching evaluation [3]. Computer vision (CV) technology has been widely applied in student behavior recognition, expression analysis, and attention detection [4]; automatic speech recognition (ASR) and speech emotion recognition (SER) have been used to analyze classroom speech content and recognize the tone and emotional state of teachers and students [5]; natural language processing (NLP) has been used to parse classroom Q&A content, assess the quality of questions, and the logic of student responses [6]. The integration of these technologies allows for the capture and modeling of multimodal classroom data, providing strong support for the intelligent and data-driven development of classroom evaluation.

Based on this, this paper aims to achieve multidimensional modeling of classroom teaching activities by integrating three core modes: visual, speech, and text through a hybrid fusion strategy, constructing a classroom teaching evaluation system

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that integrates multimodal deep learning technology [7]. This system not only quantifies student focus, participation, and teaching quality but also provides real-time feedback and personalized teaching optimization suggestions, thereby providing practical support for improving classroom teaching efficiency and quality.

2.Research Design and Methods

2.1 The overall architecture of the system

The classroom evaluation system constructed in this study adopts a multimodal deep learning architecture, combining visual, speech, and textual classroom data to achieve precise modeling and assessment of student learning behaviors and teacher teaching behaviors. The overall design of the system is based on a hybrid fusion strategy, integrating the advantages of Early Fusion and Late Fusion to enhance the model's generalization performance and robustness while maintaining the collaborative modeling capability of cross-modal features. [8].

The system's data collection module is deployed in real classroom environments, using high-definition cameras to capture visual data such as students' facial expressions, eye movement trajectories, head orientation, body movements, and teacher behaviors, analyzing students' attention levels, emotions, and interaction situations; high-sensitivity microphones are used to record teachers' spoken language and teacher-student interaction audio, identifying teachers' speech rates, tones, and emotional states, and assessing the classroom atmosphere; at the same time, automatic speech recognition technology is employed to transcribe speech into text in real-time, using natural language processing to analyze the content of teacher questions, student response logic, and keyword coverage, thereby mining the quality of classroom interactions. Data processing is divided into two phases: Early Fusion and Late Fusion. The former completes cross-modal data synchronization preprocessing at the frame, sentence, and temporal levels; the latter extracts visual features using ResNet and OpenPose models, extracts speech emotion and spectral features using CNN and LSTM, and analyzes text semantics using BERT and Transformer. Finally, high-dimensional features are fused through an attention mechanism to achieve classroom behavior classification and teaching evaluation decisions, providing data support for precise teaching optimization.

This architecture realizes an end-to-end closed-loop design from multi-source perception, feature learning to decision evaluation, with good scalability and practical application prospects, providing efficient and objective support for subsequent teaching optimization.

2.2 Modal feature extraction methods

To achieve precise perception and comprehensive evaluation of classroom teaching activities, the system performs deep feature extraction on three types of modal data: visual, speech, and text, constructing high-dimensional feature vectors that can be used for fusion modeling. Each modal feature extraction method adopts customized deep learning models based on its data characteristics to enhance feature expression capabilities and semantic understanding accuracy.

In the visual modality, the system utilizes the ResNet (Residual Neural Network) architecture to extract key emotional features from students' facial expression images. This network has strong image recognition and fine-grained classification capabilities, suitable for multi-class emotion recognition tasks, such as focus, confusion, fatigue, and joy. At the same time, to identify students' behavioral performance and participation status in the classroom, the system introduces Pose Estimation technology, selecting human keypoint detection models like OpenPose and MediaPipe to dynamically recognize and encode students' body movements (such as raising hands, writing, and bowing) and teachers' teaching methods (such as standing lectures and walking teaching). By combining facial expression and posture information, multidimensional visual behavior features reflecting student engagement and classroom atmosphere can be constructed.

In the speech modality, the system employs Convolutional Neural Networks (CNN) and Long Short-Term Memory networks (LSTM) to construct a speech feature extraction model. First, spectral features such as Mel-frequency cepstral coefficients (MFCC), Chroma, and Spectral Contrast are extracted from the audio to represent the basic physical properties of speech. Subsequently, the spectral features are input into CNN to extract spatial local features, combined with LSTM for temporal modeling to obtain dynamic information such as teachers' teaching rhythm and students' speech emotional changes. Additionally, the speech recognition front end achieves high-precision automatic speech transcription through Wav2Vec2 or DeepSpeech models, serving as the input basis for the text modality.

In the text modality, based on the classroom

dialogue text transcribed from speech recognition results, the system uses BERT (Bidirectional Encoder Representations from Transformers) to perform contextual semantic modeling of the text, identifying semantic structures and keyword distributions. This model, through a bidirectional attention mechanism, can fully understand the meaning of classroom language in context, suitable for tasks such as identifying types of teacher questions and analyzing student response logic. On this basis, the system further utilizes the Transformer structure to analyze dialogue turns, semantic depth, and knowledge point coverage, thereby extracting text features that reflect the quality of classroom interactions and content coverage.

Through the deep feature extraction of the above three types of modalities, the system achieves a multidimensional characterization of classroom behaviors, emotional states, and language content, providing rich raw data support and feature foundation for subsequent multimodal fusion modeling and teaching quality evaluation.

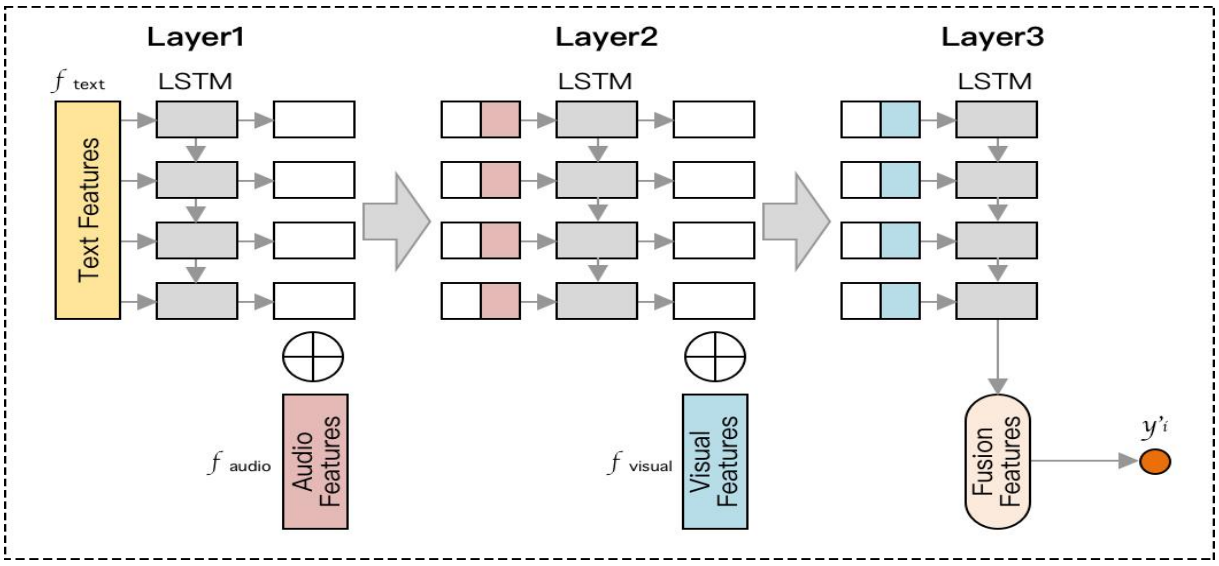
2.3 Multimodal Fusion Strategy

To achieve efficient perception and comprehensive analysis of classroom teaching behaviors, this system is designed and implemented based on the extraction of visual, speech, and text modal features, integrating deep learning and attention mechanisms through a Hybrid Fusion strategy. Multi-level information integration and modeling are performed during the input phase (Early Fusion) and decision phase (Late Fusion) to maximize the synergistic advantages of each modal feature, enhancing the model's generalization ability and evaluation accuracy.

In the Early Fusion phase, the system first completes the time synchronization and frame-level alignment of each modal data. Visual frames, speech streams, and text segments are mapped according to a unified timestamp, ensuring semantic consistency of multimodal features within the same time period. On this basis, feature concatenation is employed to initially fuse low-level feature vectors from ResNet, CNN+LSTM, and BERT models, constructing a fused representation vector as the joint input for the deep neural network. Early Fusion enhances the model's perception of cross-modal relationships, particularly suitable for assessing the comprehensive state of students at a given moment (e.g., visual focus + speech silence + short responses), aiding in fine-grained classroom behavior recognition.

In the Late Fusion phase, each modal feature is first modeled for high-level semantics through independent networks. The visual modality extracts feature maps via CNN/ResNet, the speech modality outputs temporal encodings through LSTM, and the text modality outputs contextual representations via BERT/Transformer. Subsequently, an attention mechanism or gated fusion network is used to jointly model these high-dimensional semantic representation vectors, achieving collaborative integration of multimodal semantics at the decision layer. Compared to Early Fusion, Late Fusion offers stronger interpretability and robustness, effectively avoiding modal noise interference while retaining important structural information from each modality.

Figure 1. Hybrid Fusion Model Diagram



Hybrid Fusion combines the cross-modal interaction advantages of Early Fusion with the model stability of Late Fusion, enhancing the system's ability to perceive complex classroom behaviors and improving fault tolerance for heterogeneous data, as shown in Figure 1. Experimental results indicate that the hybrid fusion structure outperforms single fusion strategies in classification tasks for key indicators such as student focus and classroom interaction quality, validating its applicability and superiority in multimodal classroom teaching evaluation.

3.Empirical Application and Result Analysis

3.1 Data Experiments and Evaluation Metrics

To verify the effectiveness of the constructed multimodal deep learning classroom teaching evaluation system, this study selected certain specialized classes from a university as empirical subjects, constructing a multimodal dataset in real teaching scenarios. Through comparative experiments and metric analysis, the system's performance and evaluation effects were comprehensively tested.

Regarding data sources, data collection was conducted in information technology classrooms and pedagogy classes, covering a total of approximately 60 teachers and students, with 12 classes collected, each lasting about 45 minutes. High-definition cameras, surround microphones, and voice collection devices were deployed in fixed teaching areas, synchronously recording the entire classroom process through legally authorized means. The collected data mainly includes:

Visual modality data: including video clips of student expressions, sequences of facial images, full-body posture behaviors (such as raising hands, writing, and bowing heads), and teacher movement trajectories;

Speech modality data: Includes recordings of teachers' lectures, teacher-student dialogues, and separated individual student speech segments;

Text modality data: Classroom speech transcribed into text using a speech recognition system (Wav2Vec2), and manually proofread for text analysis tasks.

In terms of experimental design, the study sets up three fusion strategy comparison experiments: Early Fusion, Late Fusion, and Hybrid Fusion. Each model uses uniform training parameters, batch size, and learning rate, and is trained and tested under the same dataset partition. The experimental tasks are divided into three sub-modules: student focus recognition, classroom interaction classification, and teacher lecture style assessment. Each task has manually annotated "gold standard" labels for supervised model learning and performance evaluation.

Additionally, to improve the reliability of the experimental results, this study employs 5-fold cross-validation in multiple rounds of experiments and sets up a noise scenario interference test group to simulate a non-ideal data environment in real teaching, in order to test the model's robustness and adaptability.

3.2 Experimental results

To comprehensively evaluate the performance of the constructed multimodal deep learning classroom evaluation system, this study analyzes from two dimensions: model classification accuracy and classroom teaching evaluation effectiveness. The experiments focus on student focus recognition, classroom interaction level classification, and teacher lecture style assessment as core tasks, comparing the performance of models under different fusion strategies, and demonstrating the system's interpretability and application potential with teaching examples.

In terms of model performance evaluation, the main metrics used are Accuracy, F1-score, and AUC (Area Under Curve). The performance of each fusion model on the test set is shown in Table 1:

Table 1. Performance comparison of different fusion models in key evaluation tasks

Model type	Accuracy	F1-score	AUC
Early Fusion	82.3%	0.781	0.841
Late Fusion	85.7%	0.816	0.873
Hybrid Fusion	89.1%	0.842	0.901

Note: The experiment is based on 5-fold cross-validation, covering three sub-tasks: student focus, classroom interaction levels, and teacher lecturing style.

The results show that the Hybrid Fusion model outperforms both Early Fusion and Late Fusion models on all three core metrics, indicating its strong semantic expression ability and resistance to interference while maintaining information interaction between modalities, making it suitable for complex and dynamic classroom environments.

Table 2. Accuracy of Teaching Task Classification (using Hybrid Fusion as an example)

Sub-task Type	Recognition Accuracy
Student Focus Classification	87.60%
Classroom Interaction Level Classification	91.40%
Teacher Teaching Style Score	Correlation with Manual Evaluation: 0.71

Note: The teacher teaching style score is a composite index, with a Pearson correlation coefficient of 0.71 between it and student questionnaire feedback scores.

In the student attention recognition task, the system can accurately determine students' attention states based on visual behaviors (such as eye movement trajectories and expression changes), vocal participation (such as active speaking), and classroom dialogue text features. Test results show that the Hybrid Fusion model achieves an accuracy rate of over 85% in recognizing states such as "focused," "distracted," and "confused," demonstrating strong real-time feedback capabilities.

In the classroom interaction index classification task, the model scores and classifies interaction levels by statistically analyzing teacher questioning frequency, teacher-student dialogue turns, and student raising hands/responding behaviors. The results indicate that the recognition accuracy for high-interaction classrooms reaches 91.4%, effectively distinguishing between "one-way lecturing," "low interaction participation," and "high-frequency interactive" classroom modes, providing an objective basis for optimizing teaching behaviors.

In the teacher teaching style assessment task, the system conducts comprehensive scoring modeling by analyzing indicators such as speech rate (WPM), intonation fluctuations, keyword coverage, and question openness. The teaching quality scores of teacher samples show a positive correlation with student post-class questionnaire feedback (Pearson coefficient of 0.71), further validating the rationality and credibility of the model evaluation.

Additionally, combined with the system's visualization module, personalized classroom feedback reports can be generated for teachers, including "Student Attention Heatmap," "Classroom Interaction Structure Diagram," and "Teaching Language Logical Structure Diagram," providing data support for subsequent teaching reflection and improvement. This system has demonstrated stable and accurate performance across multiple teaching evaluation tasks, validating the practicality and scalability of integrating multimodal deep learning models in intelligent classroom analysis.

3.3 Application Feedback and Teaching Optimization Suggestions

Based on the aforementioned model analysis results and classroom data mining, the multimodal classroom evaluation system constructed in this study not only possesses high evaluation accuracy and stability but also provides targeted teaching optimization suggestions for frontline teachers and educational managers, thereby promoting classroom teaching towards a more efficient, interactive, and intelligent direction. The specific optimization suggestions and system application value are mainly reflected in the following three aspects:

First, improve the quality of teachers' instruction by optimizing teaching language expression and classroom rhythm control. The system can comprehensively generate a "teaching style profile" based on teachers' speech data (such as speed, tone, and pause frequency) and textual data (like keyword coverage and questioning techniques) for the comprehensive design of teaching language expression. If teachers exhibit phenomena such as fast speech, monotonous tone, or insufficient coverage of content, the system will automatically suggest appropriate adjustments to the language rhythm of key knowledge points, enrich emotional expression, or provide supplements. Additionally, for teaching segments with low questioning frequency and a high proportion of closed questions, the system will prompt the addition of open-ended and heuristic questions to strengthen cognitive challenges in the classroom, enhancing students' deep thinking and expression abilities.

Second, enhance students' classroom focus and support personalized classroom guidance. The system identifies students' attention levels in real-time and automatically generates a "student focus report" by integrating data from visual expression features, head orientation, and vocal responses, thereby improving students' classroom focus. For students who have been

less participative or have scattered attention for a long time, the system can prompt teachers to actively ask questions, design interactive tasks, and enhance participation motivation during the teaching process. Furthermore, teachers can utilize post-class focus trend graphs to analyze the correlation between teaching content and changes in student attention, allowing for reasonable design of teaching rhythm and content structure.

Third, promote the data-driven transformation of teaching behavior reflection and research decision-making. The system supports the aggregation and analysis of historical evaluation data from multiple classroom samples, which can depict the evolution trends of teachers' teaching styles, the changing paths of classroom interaction levels, and the long-term trajectories of student participation, providing objective evidence for teaching research groups to conduct collective lesson preparation and heterogeneous analysis. At the same time, educational managers can identify high-frequency points of teaching issues based on classroom evaluation data from classes and grades, and develop targeted plans for teaching research, training, and quality improvement, thereby promoting the overall level of classroom teaching quality management in schools.

This research not only achieves precise quantification and multidimensional analysis of classroom teaching activities but also empowers teaching improvement practices through data-driven insights, showcasing significant potential for broader application. It holds important value in constructing an intelligent teaching evaluation ecosystem and promoting the digital transformation of education.

4.Conclusion and Outlook

This research addresses the issues of subjectivity, poor real-time performance, and single-dimensional information in traditional classroom teaching evaluations by constructing a multimodal deep learning-based classroom teaching evaluation system. It integrates three types of technologies: computer vision, speech processing, and natural language processing, and achieves comprehensive assessments of student focus, classroom interaction levels, and teacher instruction quality through a multi-layer Hybrid Fusion model. Experimental results indicate that the model proposed in this study demonstrates good accuracy and robustness in key evaluation tasks related to student focus, classroom interaction levels, and teacher instruction quality, possessing practical value and promising prospects for promotion. Its main contributions include: first, the introduction of multimodal deep learning fusion strategies into teaching evaluation for more objective and intelligent assessments; second, the formation of a technical path from data collection, feature extraction to fusion modeling, resulting in good generalization capabilities for the system; third, the ability to automatically generate real-time feedback and teaching optimization suggestions for classrooms, providing decision-making data for precise teaching and teaching management.

Although this research has achieved some phased results, certain limitations still exist. First, the number of samples selected for the study is relatively small, and the distribution of subjects and educational stages is quite singular; second, in some complex environments, the model's response speed and interactive feedback still have room for improvement.

Future research will expand in the following areas: first, studying multimodal small sample learning and transfer learning technologies to enhance the model's generalization capabilities; second, introducing causal inference and explainable AI mechanisms to make the logic of teaching evaluation results clearer and more accurate; third, integrating and deploying the teaching platform with this system to improve applications in intelligent classrooms and educational big data analysis. This research provides theoretical support and technical pathways for constructing a new intelligent classroom teaching evaluation system, offering beneficial explorations for future educational quality enhancement and educational evaluation reform.

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Research on the Application of Stable Diffusion-Based Generative AI Tools in Environmental Art Design Education

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Abstract: The breakthrough development of Artificial Intelligence Generated Content (AIGC) technology is reshaping the creative paradigm in the field of environmental art design. In 2023, an article on a deep learning-based model for automatic urban planning was first published in Nature Computational Science [1]. Traditional design tools are increasingly showing limitations in addressing the complexity, efficiency demands, and innovation dimensions of contemporary design needs. In contrast, generative AI tools (such as MidJourney, Stable Diffusion, etc.), through algorithm-driven creative models, demonstrate revolutionary potential in fields like architectural design, visual communication, and environmental art design [2]. These technologies can not only efficiently solve complex problems such as spatial form generation and multi-element collaborative design but also promote a paradigm shift in design thinking from "manual trial-and-error" to "intelligent evolution." In higher education, creative learning ability, as a core competency for individual lifelong development and social progress, has become an important goal in cultivating design talent [3]. This research focuses on the pedagogical innovation of generative AI in environmental art design education, using Stable Diffusion platform's Text-to-Image and Image-to-Image functionalities as the technical carriers. Through literature review, case studies, and process-based design methods, it deeply explores the application and potential for improvement of generative AI design tools in environmental art design education. Research findings indicate that generative AI provides instant visual feedback, expands the boundaries of design possibilities, and promotes human-AI collaborative innovation, bringing a technological tool revolution to environmental art design education.

Keywords: Stable Diffusion, Text-to-Image, Image-to-Image, Lora, ControlNet

1.Introduction

With the deepening promotion of sustainable development concepts in China and the growing market demand for green buildings and low-carbon design, environmental art design has become a key topic of concern for current social development and national policies. In recent years, artificial intelligence technology has shown significant application potential in fields such as landscape planning and architectural design, enabling the rapid and efficient generation and optimization of complex design schemes through AI generation tools. During this process, models based on deep learning can simulate human artistic creation, outputting artistic design patterns and spatial layouts that meet specific scene requirements. However, practical application still faces many challenges, such as inconsistent generation quality and insufficient cultural adaptability. These are not only current bottlenecks in AI technology but also major reasons hindering its deep integration into environmental art design education [4]. In the field of environmental art design education, the choice of tools directly affects students' creative efficiency and work quality. Traditional design tools like SketchUp, Figma, and the Adobe suite, despite numerous optimizations in user experience, still have limitations. For example, some tools have complex interfaces and high learning costs; functional modules are scattered, leading to reduced work efficiency; furthermore, the level of tool intelligence is limited, making it difficult to meet the

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balance sought by students and designers between creative expression and efficiency enhancement. Existing research pays less attention to the adaptability of generative AI tools in educational settings and their impact on learning outcomes.

Generative Artificial Intelligence (Generative AI) is a technology capable of automatically generating content, with its core lying in simulating human creativity. Diffusion Models, as one of the most popular generative AI techniques in recent years, are widely used in the field of art design due to their high-quality output and flexibility. Stable Diffusion, as an open-source diffusion model framework, has become an important tool for designers exploring creative expression due to its efficiency and controllability. In recent years, with breakthroughs in deep learning technology, generative AI tools such as MidJourney and Stable Diffusion have gradually become mainstream AI tools entering the design field. These tools can simulate human creativity through algorithms, rapidly generate high-quality visual elements, and provide important auxiliary functions for designers and design students.

2. The Development of Generative AI Tools

The development of generative AI tools has gone through several stages, with technological paths gradually shifting from traditional statistical models to deep learning-based generative models:

1.Early Models: Based on Markov chains, Hidden Markov Models (HMM) generation methods, with limited generation capabilities.

2.GAN Era (2014-2020): Generative Adversarial Networks (GANs) significantly improved generation quality through adversarial training between a discriminator and a generator, but faced issues like mode collapse and training instability [5].

3.VAE and Flow Models: Variational Autoencoders (VAE) and Normalizing Flows generated data through probabilistic modeling, but generation quality and efficiency were still limited.

4.Rise of Diffusion Models (2020-Present): Diffusion models generate data through a reverse process of gradual denoising. Combined with stable training and high-fidelity output, they have become the current mainstream technology. Stable Diffusion (2022) significantly reduced computational costs by compressing the diffusion process into latent space, promoting the popularization of generative AI [6].

2.1 Core Innovations of Stable Diffusion

Stable Diffusion, open-sourced by Stability AI in collaboration with several research teams, is a generative AI tool based on the Diffusion Model, widely used in image generation tasks. Its core algorithm is the diffusion model, a technique that generates high-quality images by gradually adding noise and learning the denoising process. The core idea of the diffusion model is implemented through the following two steps:

Forward Process: Gradually adds random noise to the input clear image, eventually obtaining a completely random noise image.

Reverse Process: Trains a neural network to learn how to gradually recover the clear image from the noise.

The key to the diffusion model lies in learning the "denoising" process from noise to the target image. Through extensive training data, the model can capture the details and features in the images and reproduce this information during generation.

Its core technological breakthroughs include:

1.Latent Diffusion Model (LDM): Compresses high-resolution images into a low-dimensional latent space and performs the diffusion process in this latent space, reducing computational load (traditional diffusion models operate directly in pixel space, incurring extremely high computational costs). Uses a pre-trained Variational Autoencoder (VAE) to map between images and latent space.

2.Conditional Control Mechanisms: Achieves multi-modal controllable generation through conditional inputs such as text prompts (CLIP text encoder) and image segmentation maps.Supports fine-tuning (e.g., LoRA) and plugin extensions, adapting to different vertical domains.

3.Open Source Ecosystem: Model weights and code are completely open source, fostering a rich ecosystem of community tools (like Automatic1111's WebUI) and commercial applications (art creation, advertising design, etc.).

2.2 Updates and Iterations of Stable Diffusion

Stable Diffusion is an optimized version of the original diffusion model, with major improvements including:

- Enhanced Stability: Improves the quality and consistency of generated images by adjusting parameters of the diffusion process (such as the

number of noise addition steps).

• Multi-modal Support: Besides image generation, Stable Diffusion also supports multiple task modes like text-to-image and image-to-image.

• Efficient Inference: The optimized model can complete generation tasks quickly on standard computers, reducing reliance on high-performance hardware.

3. Application of Generative AI Design Tools in Environmental Art Design Education

Table 1: Common Generative AI Models in the Context of AIGC Technology

Model Name	Generation Category	AI Model Features
Stable Diffusion	**Image/Video/3D**	- Open-source model, supports local deployment and customization. - Based on Latent Diffusion Model (LDM), high computational efficiency. - Supports multi-modal control (text, edge detection, depth maps, etc.). - Highly extensible (plugins like ControlNet, LoRA, etc.).
Midjourney	**Image**	- Closed-source commercial model, users interact via Discord. - Strong artistic stylization output (favors oil painting/sci-fi styles). - Excels at complex compositions and surreal scenes. - Does not support fine-grained control, relies on prompt optimization.
DALL·E 3	**Image**	- Text-to-image model developed by OpenAI. - Deeply integrated with ChatGPT, supports complex semantic understanding. - Generated content adheres to safety policies (automatically filters sensitive content). - Accessible only via API, no open-source version.
GPT-4	**Text/Code/Multi-modal**	- Currently the most powerful general-purpose language model. - Supports long text generation and complex logical reasoning. - Extensible to image understanding (requires integration with multi-modal interfaces). - Closed-source model, requires paid API calls.

Compared to traditional design tools, the application of generative AI design tools in environmental art design education essentially combines the "infinite imagination" of AI with the "logical control" of human designers. Its value lies not only in improving design efficiency but also in expanding the possibilities of environmental narratives. In educational settings, design tools are not just auxiliary means for teaching but also important carriers for students to cultivate creativity and practical abilities. Research indicates that the functionality and usability of tools directly affect their application effectiveness in the classroom. Students tend to prefer design tools with concise interfaces and clear functions, and believe these tools help them complete design tasks better [7]. Furthermore, the demands for design tools in educational settings have specific characteristics. On the one hand, tools need a certain degree of flexibility and extensibility to adapt to the teaching needs of different disciplines; on the other hand, the functional design of tools should focus on integration with teaching objectives, such as supporting collaborative learning and providing real-time feedback.

In environmental art design creation, the entire design process includes five stages: preliminary concept design, schematic design, design development, construction drawing preparation, and finally handover

for construction documents. The preliminary concept design is the starting point of the entire workflow and also the most crucial part. Previous concept design required significant time and effort to collect spatial intention images to determine the final direction of the scheme. Aspects like main form, design style, and functional layout all required repeated modifications and refinements to gradually perfect. Different design stages are handled by different tasks. Generative AI tools (especially Stable Diffusion) applied in the

- (Prompt-driven) Text-driven Design: In the initial stage of scheme design, students in environmental art design can simply describe the scheme using natural language: e.g., "modern minimalist city square, art sculpture integrated with sparse forest and grassland, sunny weather." Using Stable Diffusion, multiple versions of conceptual spatial renderings can be generated, breaking through

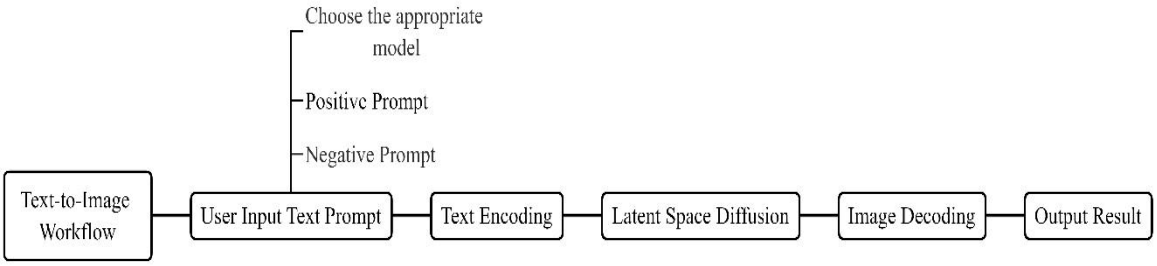
environmental art design field are thoroughly changing the traditional design workflow, demonstrating strong potential from conceptualization to scheme implementation. The following sections will illustrate its revolutionary value through application scenarios combined with specific practical examples.

Application Scenarios and Process Innovation

3.1. Preliminary Concept Design Phase: Rapidly Generate Creative Sketches, Diverge Creative Thinking

the efficiency bottleneck of traditional hand-drawing or 3D modeling. This significantly improves learning efficiency and the quality of output compared to traditional design tools.

(Model parameters: Base Model: UrbanDesign_v7, Sampler: DPM++ 2M Karras, Steps: 25, VAE: vae-ft-mse-840000-ema-pruned.safetensors, CFG scale: 8)



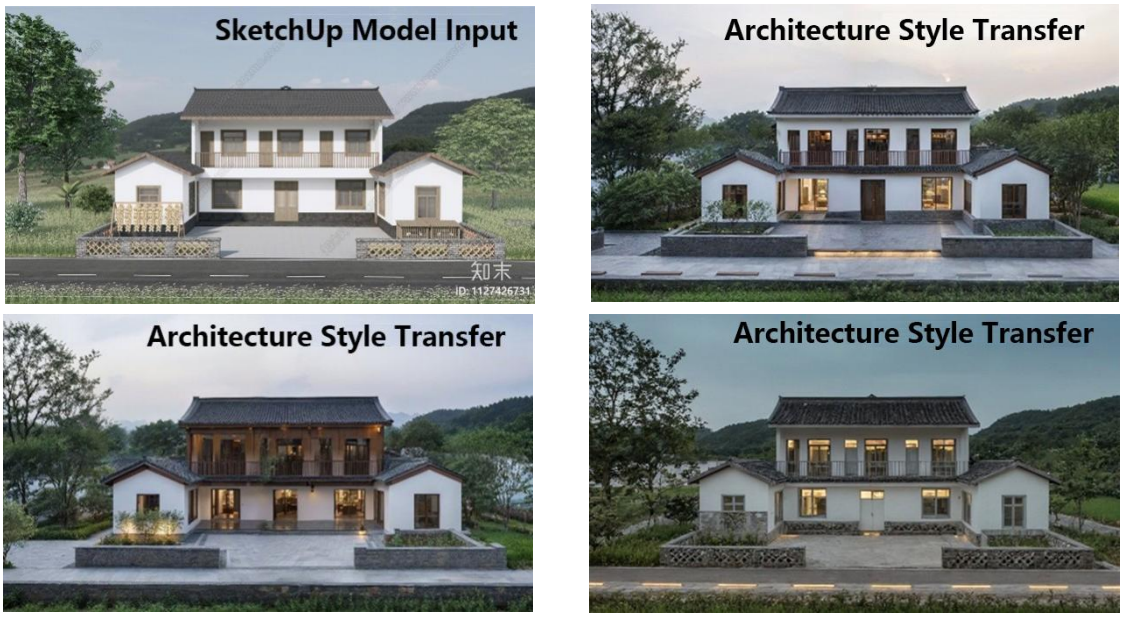
(Figure 1: Stable Diffusion Text-to-Image Workflow Diagram (Image source: Author's drawing)

(Figure 2: Scheme Generation Based on Prompt Description. Image source: Author's drawing.)

- Style Transfer (ip-Adapter): When a conceptual scheme has reached a preliminary model stage, Stable Diffusion's style transfer function can be used for secondary modification. By integrating a designated artist's style onto the project requiring modification, loading desired reference work images, and pairing with the ControlNet plugin to control building form,

customized style conceptual design schemes can be generated.

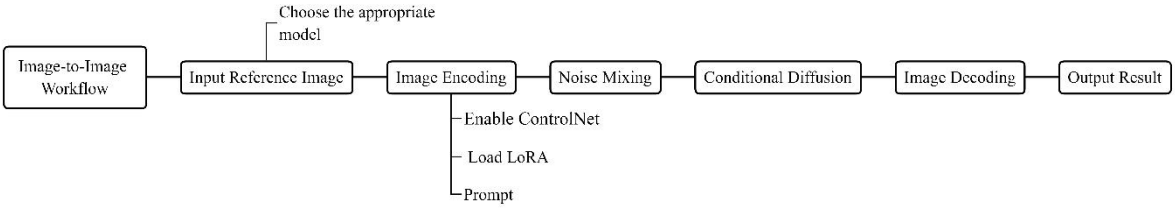
(Model parameters: Base Model: juggernautXL_v9_V9 + RDPhoto 2, Sampler: Euler a, Steps: 27, VAE: sdxl_vae.safetensors, Denoising strength: 0.28.)



(Figure 3: Style Transformation Based on SketchUp Model)

(Image source: SketchUp model image from New Chinese Style Rural Residential Collection SU Model Download [ID:1127426731]_Zhumo su Model Network. Renderings: Author's drawing)

3.2. Technical Realization: Adapting Stable Diffusion's Core Functions



(Figure 4: Stable Diffusion Image-to-Image Workflow Diagram (Image source: Author's drawing))

- **ControlNet Plugin:** Ensures structural stability of the generated scene (e.g., building form control, spatial proportions) through multi-modal model parameter adjustments like line drawing detection, soft edge detection, depth maps, semantic segmentation, etc.
- **LoRA Fine-tuning:** Trains lightweight adaptation models for specific design styles (e.g., pairing with classical gardens, future cities), enhancing the diversity and professionalism of generated content.

(Model parameters: Base Model: landscapebingV10V10_landscapebingV10, Sampler: DPM++ 2M Karras, Steps: 25, VAE: vae-ft-mse-840000-ema-pruned.safetensors, ControlNet control strength 0.85.)

(Figure 5: Spatial Rendering Generated from Scheme Line Draft)

(Image source: Line art from: https://huaban.com/pins/3747171256, Rendering: Author's drawing)

3.3. Scene Modification and Atmosphere Rendering

- **Local Iterative Optimization:** During the scheme refinement phase, perform local repainting (inpainting) on the generated renderings (e.g., replacing outdoor paving with turf, changing a swimming pool to a wooden deck) without needing to remodel, achieving the goal of modifying the image.
- **Dynamic Lighting Simulation:** Input appropriate prompts (e.g., "forest at dusk, sunlight penetrating mist forming Tyndall effect") to generate lighting effects consistent with physical laws for reference.
- **Multi-climate Condition Testing:** Quickly generate visual effects of the same scene under different weather conditions (rain, snow, sandstorm), assisting environmental narrative design and enhancing the emotional impact of the visuals.

(Model parameters: Base Model: LWANG_ARCH_MIX.V0.5Fp16Fix, Sampler: DPM++ 2M Karras, Steps: 30, VAE: vae-84m-pruned_2.0.safetensors, ControlNet line drawing control and local repainting. Control weight 1.1.)

(Figure 6: Different Environmental Spatial Renderings Generated from Scheme Line Draft)

(Image source: Line art from: Landscape Architecture Marker Pen Hand Drawing | One-Point Perspective Material - Huaban Net, Renderings: Author's drawing)

3.4. Integration with Traditional Toolchains

- **Blender Plugin:** Such as the AI Render plugin, directly imports Stable Diffusion generation results into the 3D viewport, assisting with material and lighting adjustments.
- **UE5/Unity Engine Integration:** Imports generated textures into the engine in real-time via Python scripts to test dynamic scene effects.
- **Photoshop Plugin:** Generates images based on text, supports custom resolutions. Performs style transfer or detail enhancement based on existing images. Intelligently patches missing parts of an image (requires marking repair areas with a white brush).

The core advantage of generative AI design tools lies in their ability to rapidly generate high-quality content. The intelligent production process significantly compresses the traditional design cycle. Design students can devote more energy to the preliminary creative conception and strategic optimization of the scheme. By simply inputting simple prompts, they can quickly obtain high-quality design materials, significantly improving the efficiency of the design process [8]. In addition, Stable Diffusion and MidJourney offer diverse parameter settings and style choices. Based on the model's diffusion algorithm, dynamic experiments can be conducted in dimensions such as lighting atmosphere and material texture. This "digital trial-and-error" mechanism effectively enhances the efficiency of scheme validation. It enables environmental art design students to adjust output results at any time according to requirements, generating more creative and personalized original design content, providing students with a brand-new creative experience [9]. Students can transform their

ideas into visual art, thereby gaining a sense of accomplishment and satisfaction.

4. Conclusion and Outlook

This research focuses on the innovative practical application of generative AI design tools in educational settings, systematically verifying their revolutionary value throughout the entire process of environmental art design education. Compared to traditional design workflows, generative AI tools demonstrate three significant advantages in the stages of preliminary concept deduction, scheme text generation, spatial visualization expression, and design development: First, they assist in realizing the diverse derivation and rapid iteration of creative schemes through algorithms; Second, relying on large language models, they better identify scheme prompts; Third, they employ techniques of gradually adding noise and learning the denoising process to generate high-precision spatial renderings.

Empirical evidence confirms the significant advantages of generative AI tools in improving design efficiency and stimulating creative dimensions, providing empirical support for the paradigm shift in design education. Although existing research has preliminarily explored user experience, generative AI technology, and the needs for design tools in educational settings, bringing new possibilities to design tools, their practical application in education still faces some challenges. For example, users face a relatively high threshold for operating the tools, and issues exist with the quality and consistency of generated content. Furthermore, existing research rarely focuses on the adaptability of generative AI tools in educational settings and their impact on learning outcomes. There is still a lack of systematic research framework for optimizing the functionality of design tools in educational settings. However, as the model accuracy of future AI tools increases and training data is continuously updated, the generated design images will become increasingly precise and controllable. This will drive the cultivation of design thinking from experience-led approaches towards intelligent evolution through human-AI collaboration, also providing theoretical support and practical references for environmental art design education [10].

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The Theoretical Logic of International Education Governance and the Strategic Path of China in the Context of Globalization

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Abstract: In the context of the accelerated development of globalization, international education has shifted from "transnational student mobility" to in-depth "education system governance coordination". In the face of the new challenges of the ebb of multilateralism, geopolitical risks and conflict of values, China urgently needs to establish an education governance model that is oriented to national interests and has a global consciousness in building a high-quality international education system. This paper reviews the theoretical evolution of international education governance, analyzes the strategic layout of major countries, focuses on China's current problems in international education governance, and puts forward suggestions for the path of "system coordination, cultural integration, and rule co-construction". This paper attempts to break through the previous research orientation based on technical means, and construct a theoretical framework of the international educational governance paradigm with Chinese characteristics from the perspective of educational philosophy and governance ethics.

Keywords: International Education; Education Governance; Globalization; Cultural Exchange; Strategic Path

1. Introduction

With the deepening of the globalization process, education has gradually broken through national borders, and its international connotation has become increasingly rich, from the initial cross-border flow of students and mutual recognition of academic qualifications and degrees, to a multi-dimensional collaborative process involving education system, governance system, cultural values and policy discourse. Under this trend, international education has not only become an important channel to promote knowledge flow, cultural exchanges and economic cooperation, but also gradually evolved into a core area of national soft power competition and global discourse reconstruction. Especially in the post-pandemic era, the focus on education safety, resilience and autonomy has increased significantly, and international education governance has also shown a trend of transformation from "market logic" to "governance logic".

At the same time, the global education governance landscape is facing profound adjustments. The "standard output" governance model represented by international organizations such as the OECD, the World Bank, and the United Nations Educational, Scientific and Cultural Organization (UNESCO) is being challenged, and the cultural attributes, local characteristics, and value diversity of education are increasingly valued. The evolution of the geopolitical landscape, the interaction of civilizational systems, and the transformation of learning methods driven by new technologies have caused a rift in the traditional "Western-centric" paradigm of international education governance. In particular, the global education cooperation mechanism is fragile in the face of uncertainties and risk factors, and how to seek consensus in diversity and achieve co-construction in competition has become an important proposition of international education governance.

In this context, China, as an important participant and provider of the global education system, is also facing new challenges in its international education development strategy. In recent years, China has made remarkable progress in "studying in China", Sino-foreign cooperation in running schools, and "Belt and Road" educational cooperation, and has initially

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formed an educational exchange network with certain international influence. However, at this stage, there are still problems such as fragmentation of the governance system, insufficient coordination of institutional design, and weak international communication capacity, which not only restricts the depth and breadth of education opening to the outside world, but also affects China's ability to shape discourse and lead rules in global education governance.

The academic attention to international education mainly focuses on the technical aspects such as talent training mode, cross-cultural adaptation, and policy and system design, and few studies have discussed "governance" as the core issue. The current research paradigm often relies on empirical paths or focuses on experience summarization, ignoring the deeper governance logic and value contradiction behind international education. This research gap needs to be filled urgently through theoretical reconstruction and path innovation, especially in the context of the multipolarization of the global order and the reconstruction of multilateral mechanisms, it is of great theoretical significance and practical value to explore an international education governance path that reflects the local culture, meets the needs of the times, and has the possibility of global consensus.

From the perspective of educational philosophy, international education governance should not only be regarded as an instrumental system for the allocation of national interests, but should be understood as a complex network that carries the interaction of values, cultural identity and institutional ethics. Therefore, to construct a theoretical system of international education governance with Chinese characteristics, it is necessary to go beyond the logic of a single system imitation, and explore the educational cooperation model and governance path in line with the global public interest on the basis of respecting multiculturalism, strengthening educational sovereignty, and promoting the joint construction of rules. This is not only a strategic need for China to promote education modernization and shape international discourse, but also a responsibility to respond to global education equity and the Sustainable Development Goals.

2. A Theoretical Atlas of International Educational Governance

As an interdisciplinary topic between education research and global governance research, the theoretical basis of international education governance mainly comes from the integration and development of educational sociology, comparative education, globalization studies and governance theory. In Western academia, the framework of "global governance" provides an institutional analysis tool for understanding international education, emphasizing cooperation mechanisms and policy coordination beyond sovereign states, while "new institutionalism" focuses on the imitation, integration and normative output of education systems, and believes that international organizations influence national education choices through ratings, evaluation criteria and policy discourse.

Rizvi and Lingard proposed the concept of the Global Education Policy Network, arguing that education policy is being placed in a transnational power field driven by economics, culture, and technology, which implies unequal distribution of resources and the reconstruction of cultural values. At the same time, Knight proposed the "multi-goal logic" of international education, including economic drive, academic exchange, cultural communication and diplomatic strategy, and its governance structure also presents the characteristics of diversification and multi-subject. On this basis, Marginson further emphasized the perspective of "global public goods", pointing out that international education should not only serve national strategies, but also respond to cross-cultural consensus and the construction of common human values.

On the whole, the theory of international education governance is changing from the "control-dependence" model to the "collaboration-co-construction" model, and from a one-way policy shift to multi-directional institutional interaction and value negotiation. This provides a theoretical basis and an opportunity for China to build an international education governance system with subjectivity and inclusiveness in the new era.

3. International Experiences in International Education Governance

In the education governance systems of different countries, there are significant differences in the roles and goals of international education, and their governance methods also show diverse path choices. Countries represented by the United States, Germany and South Korea have formed their own unique experience models in the design of education internationalization policies and governance

mechanisms, which have important reference significance for China to build a high-quality international education governance system.

3.1 The United States: The Governance Logic with Value output as the Core

As a major international education exporter, the United States has a highly market-oriented governance system, emphasizing the autonomy of higher education institutions and the close connection between education and economic development. Through the "Global University Ranking Mechanism", the policy of prioritizing STEM talents, and the layout of international academic networks, the United States has shaped an open international education strategy with "attracting global elites" as the core. To a certain extent, the governance of education in the United States relies on the alliance of non-governmental institutions and universities to achieve "soft law" synergy, strengthen the export of cultural influence, and show strong flexibility and adaptability in institutional arrangements.

3.2 Germany: Socially Responsible Oriented Public Governance

Germany is known for its "Kooperative Steuerung" (cooperative governance) under the federal structure, in which the state does not directly intervene in the international affairs of higher education institutions, but coordinates education policies, provides financial support, and strengthens academic mutual recognition through intermediary platforms such as "DAAD" (German Academic Exchange Service), so as to achieve effective coordination between the government and universities. Germany pays attention to the expansion of the function of "cultural diplomacy", emphasizes the two-way interaction between the public nature of education and cultural exchanges, and provides developing countries with an "equal cooperation" education aid model.

3.3 Republic of Korea: State-led Education Export Mechanism

South Korea has adopted the strategy of "state-led + industrial synergy" in international education governance, and has promoted the establishment of English-taught programs in colleges and universities, attracted foreign students and provided work visa facilitation through the formulation of medium- and long-term education internationalization strategies (such as the "Study Korea" plan), and formed an education internationalization model oriented to enhance national competitiveness. The experience of South Korea shows that in the context of countries with limited resources, the structural promotion of education internationalization can be effectively achieved through the policy guidance of the government and the institutional response of universities.

Although the experiences of the three countries have their own emphasis, they all reflect the integration trend of the three-dimensional linkage of "education-diplomacy-economy" in terms of governance concepts. They all attach great importance to the synergy between the creation of institutional environment, the combination of policy tools and the output of cultural discourse, which is of enlightening significance for China to improve the systematic and strategic governance of international education.

4. The Practical Dilemma of China's International Education Governance

Although China has made some progress in the field of international education, it still faces many practical difficulties in the construction and practice of its international education governance system, which are mainly manifested in the fragmentation of the policy system, the one-way nature of cultural communication, the uneven quality of education, and the lack of international discourse.

First, China's international education policy system is fragmented. Although in recent years, the government has gradually issued a series of relevant documents on study abroad education, Sino-foreign cooperation in running schools, and policies for international students in China, but there is a lack of a systematic and coherent long-term plan, which has led to a fault line and difficulty in coordination in the implementation of policies. Governments at all levels, education departments and universities work in silos when formulating and implementing international education policies, and it is difficult to form effective policy synergies. For example, some universities have set their own admissions standards and management systems to attract international students, while the central government's overall plans often fail to fully align with local and university operations, resulting in wasted resources and inefficient policy implementation.

Secondly, there is a certain one-way nature in the dissemination of international education and culture in China. Although China has vigorously promoted "cultural going out" in recent years, such as disseminating Chinese culture through projects such as Confucius Institutes, it is often limited to a one-way export model and lacks real cultural exchange and

interaction. The fundamental goal of international education should be to promote understanding and respect between different cultures, not simply to export cultures. Strategies that place too much emphasis on the export of "soft power" may create a negative impression of cultural hegemony in the international community and limit the diversity and inclusiveness of educational cooperation and cultural dialogue.

In addition, China's quality assurance and evaluation system for international education is not yet perfect. Although some universities and educational programs have reached international standards, there is still a gap in the stability of education quality and international recognition. Most of China's international education programs use English as the main language, and there is a lack of cross-cultural and multicultural educational design, which limits the participation and adaptability of students from different countries and regions. In addition, some Chinese-foreign cooperatively-run schools have problems such as imperfect management system and unreasonable curriculum system, which affects the learning experience and education quality of international students.

Finally, China's voice in global education governance is still weak. Despite China's growing importance in the global education system, its dominance over global education standards, assessment systems, and policy issues remains limited. When China participates in global education decision-making, it is mostly limited by the existing international education system and norms, and it is difficult for China to fully express and defend its position in international education governance.

5. A Strategic Path to Build an International Education Governance System with Chinese Characteristics

In the context of the reform of the global education governance system, China is facing both opportunities and challenges in building an international education governance system. In order to modernize education and enhance its international discourse, China needs to build an international education governance model with Chinese characteristics from a strategic perspective. This model should focus on coordinating domestic and foreign educational resources, strengthening the diversity and integration of cultural identity, and promoting the modernization and institutional innovation of the international education governance system.

First of all, to build an international education governance system with Chinese characteristics, it is necessary to strengthen institutional integration and collaborative innovation. At present, China's policy system in international education governance is still fragmented, and there is a lack of long-term mechanism and systematic design. To this end, the government should strengthen the overall planning of international education, formulate an international education development strategy in line with national conditions, and enhance policy consistency and implementation through cross-departmental and cross-regional coordination mechanisms. The Ministry of Education can integrate the educational resources of various localities and colleges and universities by organizing a national education cooperation platform to form a joint force; At the same time, we should strengthen cooperation among international organizations, jointly participate in the formulation and evaluation of global education governance rules, and promote the formation of an international education governance framework with Chinese characteristics.

Second, cultural inclusion should be at the core of international education governance with Chinese characteristics. In the process of promoting international education, China should not only pay attention to the quantity and breadth of education exports, but also pay attention to the depth and interaction of cultural exports. In this regard, it is particularly important to emphasize the concept of "cultural co-construction". China should strengthen educational and cultural exchanges with other countries, and promote understanding and mutual learning among different cultures through innovative educational programs and cultural experience activities. Through two-way interactive cultural exchanges, it can not only enhance the global influence of Chinese culture, but also enhance the international competitiveness of China's education system. In addition, China should strengthen its inclusiveness and adaptability to foreign cultures, respect the educational and cultural characteristics of other countries, and achieve win-win results in cooperation.

Third, the internationalization and standardization of education quality is the key to improving China's international education governance capacity. China needs to strengthen the integration of the education quality assurance system with the international education system, and promote the unification of quality certification and evaluation standards for international education programs. In particular, China

should formulate stricter quality standards and establish a sound quality supervision and evaluation mechanism for the "Study in China" program and Sino-foreign cooperation in running schools. This will not only help to enhance the international reputation of Chinese education, but also enhance the learning experience and satisfaction of international students. Through close cooperation with international education organizations, we will promote the global standardization of the education quality assurance system and enhance the global competitiveness of Chinese education.

Finally, China should actively participate in the rule-building and discourse struggle for global education governance. China should make full use of its economic and cultural advantages in global education governance to promote a fairer, more open and more inclusive international education environment. In particular, driven by the concept of "global education public goods", China should actively advocate the sharing of global educational resources and mutual benefit of cooperation, and promote the reform and innovation of global education cooperation mechanisms. Through platforms such as the Belt and Road Initiative, China can deepen educational cooperation with developing countries, establish a more equal international education cooperation system, and promote the development of a more diversified and cooperative global education governance mechanism.

6. Conclusion

In the context of globalization, international education governance is not only an important task for education development, but also a key area for countries to enhance their soft power and promote cultural exchanges and international cooperation. In the process of promoting international education, China faces many practical difficulties, but at the same time, it also has unique development opportunities. To build an international education governance system with Chinese characteristics, it is necessary not only to strengthen coordination and integration in institutional innovation, but also to achieve a higher level of internationalization in cultural exchanges and education quality.

Looking ahead, China is expected to play a more important role in global education governance. In the era of increasingly fierce competition in global education, China not only needs to achieve breakthroughs in the allocation of educational resources, quality improvement and talent training, but also enhances the international discourse power and the influence of global education governance through multicultural exchanges and cooperation. By deepening education cooperation with other countries and promoting co-construction and sharing, China will be able to contribute more wisdom and strength to the sustainable development of global education.

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Research on the Innovative Talent Cultivation Mechanism of Music in Higher Vocational Colleges under the "Double High" Background: Dilemmas and Breakthroughs

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Abstract: Under the "Double High Plan" promoting high-quality vocational education, this study addresses critical challenges in cultivating innovative music talents (e.g., curriculum-market misalignment, insufficient faculty innovation, inadequate practical platforms). Drawing on domestic and international best practices (e.g., Berklee, CCOM, SZPT), it systematically constructs a six-dimensional cultivation mechanism: innovative goal setting (versatile, application-oriented, innovative), interdisciplinary curriculum optimization, diversified teaching method innovation (project-based, case-based, etc.), "dual-qualified" faculty development, industry-education integrated practical platform enhancement, and diversified evaluation system establishment. The research aims to guide music education reform in higher vocational colleges towards cultivating high-quality innovative music talents, thus serving national cultural strategies and industrial upgrading.

Keywords: Double High Plan context; Higher vocational colleges; Innovative music talents; Training mechanism; Industry-education integration; Curriculum reform; Faculty development

1. Introduction

1.1 Research Background and Significance

With the continuous deepening of higher vocational education reform in China, the implementation of the "Double High Plan" has raised higher requirements for talent cultivation in higher vocational colleges. Against this background, how music education in higher vocational colleges can cultivate innovative professional talents to meet the needs of the new era's music industry and cultural development has become an urgent issue to be addressed.

The "Double High Plan" aims to concentrate efforts on building a group of higher vocational schools and professional clusters that lead reform, support development, possess Chinese characteristics, and reach world-class standards. It drives the continuous deepening of vocational education reform, strengthens connotation construction, and achieves high-quality development. For music majors in higher vocational colleges, this means breaking the traditional talent cultivation model and placing greater emphasis on improving students' innovation ability, practical skills, and comprehensive quality. In the context of cultural diversity and the rapid development of the music industry, society's demand for music talents tends to be diversified and high-end. Besides requiring talents with solid professional skills, there is a greater need for compound talents with innovative thinking who can adapt to emerging fields. With the rise of emerging industries such as digital music, music technology, and music cultural creativity, the demand for compound talents integrating music with technology, culture, and creativity has increased. However, currently, higher vocational colleges face problems in music talent cultivation regarding teaching concepts, curriculum design, and teaching methods, making it difficult to meet the needs of innovative talent cultivation. Some colleges overemphasize skill training while neglecting the cultivation of innovative thinking and comprehensive quality; the curriculum system is outdated and inconsistent with market demands; teaching methods are monotonous and fail to

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stimulate students' autonomous learning and innovation abilities.

This study holds significant theoretical and practical value. Theoretically, it enriches the theoretical system of music talent cultivation in higher vocational education and provides new perspectives for academic research. Practically, it guides higher vocational colleges to optimize music major curricula and teaching, improve talent cultivation quality, promote music education policy formulation, and advance music education reform and cultural prosperity.

1.2 Current Research Status at Home and Abroad

Abroad, vocational education systems are relatively mature and have unique concepts and methods for music talent cultivation. Taking the United States as an example, many community colleges' music programs emphasize close connections with the local music industry. Through school-enterprise cooperation projects, students accumulate experience in practice and develop practical skills. Germany's "dual system" vocational education model is also applied to some extent in the music field, where students spend half their time learning theoretical knowledge at school and the other half practicing in enterprises or music institutions. This model emphasizes the cultivation of practical abilities, enabling students to quickly adapt to job requirements. Some art schools in the United Kingdom focus on interdisciplinary integration in music talent cultivation, encouraging students to combine music with technology, cultural creativity, and other fields, thereby cultivating music talents with innovative thinking and comprehensive abilities.

In recent years, domestic research on the cultivation of music talents in higher vocational colleges has also achieved certain results. Scholars have explored issues such as talent cultivation models, curriculum systems, and teaching methods from different perspectives. Regarding cultivation models, some studies propose combining market demand to build an "order-based" talent cultivation model, signing cooperation agreements with music enterprises, and customizing talent cultivation programs according to enterprise needs to enhance students' employability. In terms of curriculum systems, some research suggests optimizing course offerings, increasing the proportion of practical courses, and offering courses related to emerging music fields, such as music production and music marketing, to broaden students' knowledge base and employment channels. In teaching methods, project-driven teaching and group cooperative learning are advocated to stimulate students' learning enthusiasm and innovation ability.

Research shows that higher vocational colleges have shortcomings in cultivating innovative music talents, especially under the "Double High" background. Although there is research on innovation ability, it has not deeply integrated the goals of the "Double High" plan and lacks a systematic discussion of cultivation mechanisms under the demands of the new era. In teaching practice, there is insufficient research on methods for cultivating innovative thinking and abilities; most studies focus on improving traditional teaching methods and lack a complete theoretical and practical system to stimulate students' innovative thinking and abilities. Meanwhile, the evaluation system for cultivating innovative music talents is also imperfect, with main evaluation indicators focusing on professional skills and theoretical knowledge, lacking comprehensive and scientific assessment of innovation ability and overall quality.

1.3 Research Methods and Innovations

This study employs multiple methods to ensure scientific rigor, comprehensiveness, and depth. Based on literature research, it extensively reviews relevant domestic and international materials, summarizes research achievements, clarifies the current research status and development trends, and provides theoretical support. The case study method selects representative higher vocational colleges' music majors to deeply analyze the practice and issues of cultivating innovative music talents. The survey method collects opinions and suggestions through questionnaires and interviews to understand the actual situation and needs of cultivating innovative music talents.

The research perspective closely aligns with the "Double High" background, examining the cultivation mechanism of innovative music talents and providing ideas for the reform of music education in higher vocational colleges. The research content systematically constructs a theoretical framework for cultivating innovative music talents in higher vocational colleges and proposes innovative and practical suggestions and measures, offering comprehensive guidance for the practice of music education in these institutions.

2. The Importance of Cultivating Innovative Music Talents in Higher Vocational Colleges under the "Double High" Background

2.1 The Era Value of Cultivating Innovative Music Talents

Innovative music talents play a key role in cultural inheritance and innovation. They integrate traditional culture with modern elements, giving new vitality to music. By rearranging traditional music with modern technology, they attract young people's attention and promote the inheritance and development of national music culture. Innovative music works inject new energy into music culture, promote the exchange and integration of different music cultures, and enrich cultural diversity.

Innovative music talents are the core driving force for upgrading and innovating the music industry. They create music works that meet market demands, lead music trends, promote the upgrading of music production technology, and enhance the commercial value of music performance. At the same time, they explore new models in the music industry, such as the integration of music with technology and cultural tourism, promoting innovation and economic growth in the music industry.

Innovative music talents also play an important role in social and cultural construction by creating positive energy music works that convey positive values and enrich people's spiritual world. They participate in public cultural activities to meet people's needs for cultural arts and improve the quality of social cultural life. By using music to promote group communication and enhance social cohesion, they inject new vitality into social and cultural construction.

2.2 The Unique Advantages of Cultivating Innovative Music Talents in Vocational Colleges

Higher vocational colleges have unique advantages in cultivating innovative talents in music, providing strong support to meet the demands of the new era.

Higher vocational colleges possess abundant practical teaching resources, including advanced facilities such as recording studios, music production laboratories, and multifunctional rehearsal halls, offering students an environment for hands-on practice. Through participation in music recording, production, and rehearsals, students enhance their musical skills and stage performance abilities. The curriculum emphasizes the integration of theory and practice, such as music performance planning and organization, enabling students to comprehensively understand music project operations and improve their ability to solve practical problems.

Higher vocational colleges maintain close cooperation with music industry enterprises, establishing internship bases and jointly conducting talent cultivation and project collaboration. Enterprises provide schools with industry trends, while schools supply talents to meet enterprise needs. Industry experts participate in teaching, sharing practical work experience to improve students' professional qualities and employability.

The rich practical teaching resources and industry connections of higher vocational colleges provide students with practical opportunities and career development platforms, cultivating music innovative talents with professional skills, innovative thinking, and practical abilities to meet social demands.

3. Analysis of the Current Situation of Innovative Talent Cultivation in Music at Higher Vocational Colleges

3.1 Demand for Reform of the Music Major Curriculum System

The music major curriculum system has unreasonable aspects that make it difficult to meet the needs of innovative talent cultivation. The curriculum lacks systematicness and foresight, neglecting emerging music fields, resulting in a single knowledge structure for students. The curriculum connection is loose, with knowledge repetition and disconnection phenomena, affecting students' formation of a systematic knowledge system. Teaching content is outdated and slow to update, limiting students' innovative thinking and creative abilities. Teaching methods are traditional and lack cultivation that stimulates students' innovative thinking and practical abilities. Practical teaching forms are single and lack cooperation with off-campus music institutions and enterprises, affecting students' practical skills and innovation capacity development. The faculty structure is unreasonable; the academic qualifications and professional titles affect the overall quality and innovation ability of the teaching staff. Some teachers' teaching abilities need improvement, lacking innovation awareness and practical skills. Insufficient practical teaching and platform construction hinder the enhancement of students' innovation abilities. Higher vocational colleges need to strengthen faculty development, optimize faculty structure, improve

teacher quality, and enhance practical teaching and platform construction to meet the demands of cultivating innovative talents.

4. Challenges Faced by Higher Vocational Colleges in Cultivating Innovative Music Talents under the "Double High" Background

4.1 Disconnection between Curriculum System and Market Demand

The music curriculum of higher vocational colleges is disconnected from market demand, affecting the cultivation of innovative talents. Insufficient practical teaching leads to a curriculum system that does not align with market needs. Students find it difficult to encounter real market demands during on-campus practical activities, limiting their ability to solve practical problems. Higher vocational colleges need to strengthen research on market demand, update curriculum content, increase the proportion and depth of practical teaching, cooperate with music enterprises, and build a curriculum system aligned with market demand to cultivate music innovative talents adapted to the new era.

4.2 Insufficient Innovation Capability of the Faculty Team

The faculty team of music education in vocational colleges lacks innovation, which affects the cultivation of innovative talents. Teachers' insufficient innovation ability makes it difficult to meet the rapidly developing demands in the music field. They have inadequate understanding of new techniques and concepts in modern music composition and cannot effectively guide students. Their limited mastery of emerging music composition software and technologies restricts students' innovative capabilities. To meet the requirements of cultivating innovative talents, vocational colleges must strengthen faculty development, enhance teachers' innovation awareness, abilities, and practical experience, providing strong faculty support for the cultivation of innovative music talents.

5. Experience Reference from Domestic and International Universities in Cultivating Innovative Music Talents

5.1 Models and Cases of Innovative Music Talent Cultivation in Foreign Universities

Foreign universities have rich experience in cultivating innovative music talents, with the Berklee College of Music in the United States being particularly outstanding.

Berklee College of Music offers a diversified curriculum covering various music styles, including specialized courses such as music production, film scoring, and music business management. Its practical teaching model is a highlight, providing abundant practical opportunities such as concerts, live performances, and recording production. Cooperation with the music industry offers students internships and employment opportunities.

Berklee graduate John Mayer utilized the school's resources and practical opportunities to enhance his musical skills. After graduation, he became a well-known music composer and performing artist, winning honors such as the Grammy Awards, which proves the college's success in cultivating innovative music talents.

5.2 Exploration and Practice of Innovative Music Talent Cultivation in Domestic Universities

Domestic universities actively cultivate innovative music talents. The Central Conservatory of Music has achieved remarkable results in industry-university-research cooperation. By collaborating with symphony orchestras and establishing practical platforms, students improve their professional skills and artistic literacy through participation in rehearsals and performances.

Both parties are committed to re-staging classic repertoires and creating original works. Faculty and students of the Central Conservatory of Music collaborate with orchestra musicians to explore new ideas in music composition, promoting innovative development in music creation. Students integrate different musical elements in their compositions, producing works that are innovative and contemporary. The Central Conservatory of Music and the China Symphony Orchestra share music literature and academic achievements, facilitating the integration of theoretical research and practice. By accessing more musical materials, students deepen their understanding and analytical abilities of musical works, while teachers' teaching and research are also innovated and improved.

Taking the original symphonic work "Dawn of the New Era" as an example, the piece combines traditional and modern musical techniques to showcase the spirit of the new era. During the creative process, students conduct in-depth research on Chinese traditional music culture and pay attention to modern

music trends, producing works with a unique style. Orchestra musicians carefully rehearse and perform the piece, perfectly presenting it on stage and demonstrating the achievements of the Central Conservatory of Music in cultivating innovative musical talents.

Table 1: Comparison of Domestic and International Higher Education Institutions' Experiences in Cultivating Innovative Music Talents

Case	Training Model	Core Measures	Outcomes
Berklee College of Music, USA	"Technology + Art + Industry" Integration Model	① Offering courses such as AI Music Production and Music Business Management; ② Co-establishing training bases with Apple Music and Spotify; ③ Encouraging students to participate in Grammy-level project practices.	Graduates have a 92% employment rate in the digital music industry, a 15% entrepreneurship rate, and an average starting salary 30% higher than the industry average.
Central Conservatory of Music	"Industry-University-Research-Application" Collaborative Model	① Establish a Music Artificial Intelligence Research Center; ② Collaborate with the China Symphony Orchestra to carry out the "New Works Creation Program"; ③ Launch the interdisciplinary course "Music Technology Workshop"	The number of awards won by students in domestic and international innovation competitions has increased by an average of 25% annually, and the commercial conversion rate of original music works has improved by 40%.
Shenzhen Polytechnic	"Post-Course-Competition-Certificate" Integration Model under the "Double High" Guidance	① Develop 1+X certificate courses such as "Digital Music Arrangement and AI Applications"; ② Host the National Vocational College Music Innovation Competition; ③ Co-establish a Virtual Orchestra Training Center with Tencent Music.	The employment rate of graduates in related fields is 91%, the number of provincial-level and above skill competition awards has increased by 180% over three years, and enterprise satisfaction reaches 95%.

6. Construction of an Innovative Talent Training Mechanism for Music in Higher Vocational Colleges under the "Double High" Background

6.1 Innovative Talent Training Goals and Positioning

Under the "Double High" background, music education in higher vocational colleges needs to innovate training goals to meet the demands of the new era and cultivate high-quality music talents. Clarify objectives, optimize talent positioning, and emphasize the cultivation of innovative spirit and practical abilities.

"The 'Double High' plan requires cultivating talents with innovation, practical skills, and comprehensive qualities to serve national strategies and industrial upgrading. The music major should train students with solid music knowledge, skills, and high-level performance, singing, and composition abilities, emphasizing innovative thinking and awareness. Courses on musical innovative thinking should be offered to guide students to break through traditional thinking and try new musical elements and creative

concepts. Open-ended creative topics should be set to encourage students to engage in innovative music creation practices. Cooperation with music enterprises should be established to provide practical opportunities, allowing students to participate in music performances, production, teaching, and other projects to accumulate experience.

Market demand is an important guide for the cultivation of music talents. With the rapid development of the music industry, society requires diversified and high-end music talents. Vocational colleges should pay attention to market changes, adjust talent cultivation positioning, and meet these demands.

For emerging fields such as digital music, music technology, and music cultural creativity, it is essential to cultivate talents with relevant technologies, knowledge, and skills. Collaborate with music enterprises to jointly carry out talent cultivation, offering courses like digital music production and music software applications, and train talents in music performance planning and organization.

6.2 Optimization of Curriculum System and Teaching Content

Building a curriculum system centered on innovation ability is key to the reform of vocational music education. Under the "Double High" initiative, traditional constraints should be broken, focusing on the systematic, forward-looking, and interdisciplinary nature of courses to cultivate students' comprehensive abilities and innovative thinking.

Increasing interdisciplinary courses is an important way to cultivate students' innovative abilities. Music is closely linked with technology, cultural creativity, marketing, and other disciplines. Offering interdisciplinary courses broadens knowledge and cultivates comprehensive abilities and innovative thinking. For example, courses such as music production technology, digital audio processing, and music artificial intelligence cultivate students' innovation abilities in the field of music technology. Courses like music cultural creativity planning, music event organization and promotion develop cultural creativity and marketing skills. Courses in music marketing and music copyright management cultivate market development and business operation capabilities.

The practical teaching component is crucial for cultivating innovation and practical abilities. The proportion of practical teaching should be increased, enriching its forms and content. Besides on-campus activities, cooperation with off-campus institutions and enterprises should be strengthened to provide more internships and practical opportunities. Collaborate with music performance companies to allow students to participate in planning, organizing, and executing events, gaining an understanding of industry operations and market demands; cooperate with music production companies to improve music production skills and innovation capabilities. Encourage participation in music cultural exchanges and public welfare activities to cultivate social responsibility and innovative spirit.

6.3 Innovation in Teaching Methods and Means

Innovative teaching methods, such as project-based learning, drive students to comprehensively apply knowledge and skills through real projects, cultivating problem-solving and innovation abilities.

6.4 Strengthening the construction of the teaching staff

Strengthening the teaching staff is crucial for improving the quality of music education in vocational colleges and cultivating students' innovative abilities. To cultivate a high-quality, innovative "dual-qualified" music teaching team, the following measures can be taken.

Regularly train teachers, including cutting-edge music knowledge, innovative teaching concepts and methods, as well as digital music production technologies such as Ableton Live and FL Studio, to impart the latest knowledge and skills. Emphasize training in innovative teaching methods, such as project-based learning and case teaching, to stimulate students' interest and innovative thinking. Invite experts and innovators to share educational philosophies and experiences, enhancing teachers' awareness and ability for innovation.

Encourage teachers to participate in music practice activities, such as performances, composition, and production projects, to accumulate practical experience and improve teaching ability. Participate in seminars and exchange meetings to understand industry trends, providing references for teaching and research.

Attract professionals with rich industry experience and high academic qualifications to join the teaching staff, optimizing the faculty structure. Provide preferential policies and favorable conditions, such as advanced teaching equipment and research support, to broaden talent recruitment channels. Cooperate with

specialized institutions to recruit outstanding graduates and actively introduce professional talents.

"Dual-qualified" teachers combine theory and practice to cultivate innovation and practical abilities. Establish evaluation standards, clarify requirements, assess practical experience, and evaluate teaching capabilities. Improve the training mechanism by providing practical opportunities and training resources, cooperating with enterprises to establish practice bases, organizing skills training and certification exams, and enhancing teachers' practical skill levels.

Table 2：Innovative Applications in Music Teaching Methods

Teaching Methods	Application Fields	Student Ability Cultivation	Teaching Effectiveness
Project-Based Learning Method	Music Production Course	Ability to Solve Practical Problems and Innovate	Master Music Production Techniques and Create Unique Style Soundtracks
Case Teaching Method	Music Performance Course	Ability to Analyze and Solve Problems	Improve performance level by learning from the experience of outstanding musicians
Group Cooperative Learning Method	Music Composition Course	Team Collaboration Ability and Innovation Ability	Create More Creative and Personalized Music Works
Multimedia Teaching Tools	Music Appreciation Course	Enrich Teaching Resources and Improve Teaching Effectiveness	Provide Vivid and Intuitive Learning Experience
Online Teaching Platform	Independent Learning	Convenient learning channels, personalized learning services	Learn and communicate anytime, anywhere, meeting personalized learning needs
VR and AR technologies	Music performance teaching	Immersive learning environment, enhancing the learning experience	Improve stage performance ability, stimulate innovative thinking and creative enthusiasm

6.5 Improvement of Practical Teaching and Platform Construction

Practical teaching is crucial for cultivating innovative talents in music at vocational colleges, helping to enhance students' innovation and practical abilities. Through music performance practice, such as planning, organizing, and performing, students can strengthen organizational coordination, stage performance, and innovation skills, as well as improve their ability to respond to emergencies.

Vocational colleges should cooperate with music enterprises and cultural institutions to establish practical teaching bases. The cooperation includes music production practice bases for students to learn music production technology; music performance practice bases providing performance opportunities; and organizing music cultural activities to improve students' musical literacy.

In cooperation, both parties' rights and obligations should be clearly defined, with cooperation agreements and management systems established. Enterprises should provide resources and professional guidance, while colleges formulate teaching plans, organize activities, and evaluate student performance. Both sides need to strengthen communication to jointly improve the quality of practical teaching.

The construction of on-campus innovation practice platforms is equally important for cultivating

students' innovative abilities. Colleges should invest in building music innovation studios equipped with advanced equipment to encourage innovative creation; establish music innovation funds to support outstanding projects; and organize innovation competitions and activities to stimulate students' enthusiasm for innovation.

Improving practical teaching and platform construction provides students with opportunities for practice and presentation, cultivates innovation and practical abilities, enhances comprehensive quality and employment competitiveness, and supports the cultivation of innovative music talents.

6.6 Establishment and Improvement of the Evaluation System

Constructing a scientific evaluation system is vital to ensure the quality of innovative talent cultivation in music at vocational colleges. This system should comprehensively assess students' learning outcomes and innovative abilities, covering music theory, professional skills, innovation and practical abilities, and comprehensive qualities. The evaluation methods should combine formative and summative assessments, including classroom performance, assignments, group projects, exams, and work presentations. The evaluators should be diversified, including teachers, student self-assessment and peer assessment, and industry enterprise evaluations, to fully reflect students' learning status.

7. Conclusion and Outlook

7.1 Research Summary

This study explored the mechanism for cultivating innovative music talents in higher vocational colleges under the "Double High" initiative, analyzed the current situation and challenges, and drew on domestic and international experiences to construct a comprehensive mechanism. Problems such as unclear objectives, outdated curricula, and monotonous teaching methods exist in the cultivation of innovative music talents in higher vocational colleges. By referencing the experiences of Berklee College of Music and the Central Conservatory of Music, higher vocational colleges need to improve practical teaching, faculty teams, curriculum systems, and cultivation concepts. The constructed mechanism aims to cultivate high-quality music talents with professional knowledge, innovative spirit, and practical ability, optimize the curriculum system, integrate theoretical and practical courses, increase the proportion of interdisciplinary and practical teaching, and update teaching content. Diverse teaching methods and modern information technology are adopted to stimulate students' interest and innovative thinking. Faculty team building is strengthened to enhance teachers' professional quality and innovation ability, creating a "dual-qualified" music faculty team. Practical teaching and platform construction are improved by strengthening cooperation with music enterprises and cultural institutions, establishing practical teaching bases, and building on-campus innovation practice platforms. A diversified evaluation system is established to comprehensively assess students' learning outcomes and innovative abilities.

7.2 Research Limitations and Prospects

This study has achieved results but also has limitations. The case analysis is limited to some higher vocational colleges, restricting the generalizability of the research. The depth of investigation needs to be enhanced, and some in-depth issues have not been thoroughly analyzed. Future research should expand the scope of cases to enhance universality and guiding significance. Dynamic research should be strengthened to focus on new industry requirements and adjust talent cultivation mechanisms accordingly. Technologies such as big data should be utilized to deeply analyze music education data and provide scientific evidence. International comparative studies should be conducted to explore new music education models suitable for China. This will provide theoretical and practical guidance for cultivating innovative music talents in higher vocational colleges.

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From Hope to Anxiety: The Interaction Mechanism of Educational Expectations and Social Pressures in College Students' Families

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Abstract: This study theoretically explores the interaction mechanism between educational expectations and social pressure in college students' families. By analyzing the relevant theories of sociology, psychology and education, this paper reveals how the high educational expectations of families for college students are affected by the social environment, and how this expectation interacts with social pressure, which in turn affects students' academic performance and mental health. Studies have pointed out that families' educational expectations may be transformed into students' anxiety under the transmission of social pressure, which may further affect students' academic development and mental health. This paper puts forward theoretical suggestions for optimizing family education strategies, in order to provide useful guidance for college students' families and promote students' all-round development.

Keywords: College Students; Family; Educational Expectations; Social Pressure; Interaction Mechanism

1.Introduction

In today's society, education is widely seen as a key pathway to personal development and social mobility. Families' expectations for their children's education are generally high, especially among families of college students. Parents generally hope that their children will be able to obtain a high degree through higher education, so that they can occupy an advantageous position in social competition, and achieve the social status and economic improvement of the family (Bourdieu, 1986; Coleman, 1988). This expectation is not only derived from parents' visions of their children's future lives, but is also influenced by socio-cultural contexts **(Bourdieu,1986; Coleman,1988).** The general recognition of high education and the high treatment of highly educated talents make parents think that education is an important means to change their destiny and achieve social mobility. However, the formation of educational expectations does not exist in isolation, it is affected by a combination of factors such as family economic conditions, social class, cultural environment, etc. Society's high expectations for educational success make families feel great pressure in the process of educating their children, not only from the economic burden, but also from the intensification of social competition and fierce competition for educational resources.

With the intensification of social competition and the rising cost of education, families are facing increasing pressure in the process of educating their children. Society's emphasis on high education and professional status has put families under tremendous pressure to educate their children. Parents are worried that their children will fall behind in the fierce competition, so they continue to raise their expectations for their children's education. This expectation reflects not only parents' expectations for their children's future success, but also parents' anxiety about their own social status. The intensification of social competition has intertwined the family's educational expectations for their children with social pressures, forming a complex interactive relationship. Social pressure acts on students through the transmission of family expectations, which may lead students to feel greater academic pressure and psychological burden. This stress not only affects a student's academic performance, but can also have a negative impact on a student's mental health. Studies have shown that high educational expectations of families can motivate students to work hard to a certain extent, but if the expectations are too high, it

may lead students to feel greater pressure, which in turn affects their learning effectiveness and mental health.

The purpose of this study was to explore the interaction mechanism between educational expectations and social pressure in the families of college students. By analyzing the relevant theories of sociology, psychology and education, this paper reveals how the high educational expectations of families for college students are affected by the social environment, and how this expectation interacts with social pressure, which in turn affects students' academic performance and mental health. Understanding this interaction mechanism is of great significance for optimizing family education strategies and alleviating students' academic stress and anxiety. This study not only helps to enrich and improve the theoretical framework of educational expectations and social pressures, provides a new perspective for understanding the educational phenomenon in college students' families, but also provides scientific suggestions and guidance for families, schools and society, and promotes the all-round development of students. Through the in-depth study of the interaction mechanism between educational expectations and social pressure, we can better understand the educational phenomenon in the families of college students, and provide theoretical support and practical guidance for cultivating well-rounded high-quality talents.

2. Theoretical Background

2.1 Sociological Theoretical Perspective

(1) Social Class Theory

Social class theory holds that the unequal distribution of social resources leads to differences between different classes. In the field of education, the economic, cultural and social capital of the family has a significant impact on children's educational opportunities and achievement (Bourdieu, 1986). Higher-class families are often able to raise their educational expectations by providing their children with more educational resources and opportunities (Bourdieu, 1986; Lareau, 2011）。 However, the intensification of social competition has made even high-class families feel greater pressure, and this pressure is passed on to their children through the family, which can lead to anxiety among students.

(2) Social Exchange Theory

Social exchange theory emphasizes the costs and benefits of individuals in social interactions. Families' high educational expectations for their children can be seen as a social investment, and parents hope to gain social status and financial rewards through their children's high education (Coleman, 1988). However, the cost of such an investment (e.g., financial burden, time commitment, etc.) can also be stressful for families and students. If a student fails to meet their parents' expectations, it can lead to a "failed investment" for the family, which can trigger feelings of anxiety.

2.2 Psychological Theory Perspective

(1) Expected Value Theory

Expectation theory states that an individual's motivation depends on his or her expectation of success and his subjective value to success (Eccles & Wigfield, 2002). In educational contexts, parents' high educational expectations may motivate students to work hard, but if students feel excessive pressure, it may reduce their subjective value to success and thus affect their motivation to learn (Eccles & Wigfield, 2002). In addition, excessively high expectations can lead to an increased fear of failure in students, which in turn can lead to anxiety.

(2) Social Comparative Theory

Social comparison theory states that individuals evaluate their abilities and achievements by comparing them to others (Merton, 1957). In the collegiate setting, students are compared to their peers, especially in terms of academic performance and career development (Bandura, 1977; Vygotsky, 1978 ）。 Parents' high educational expectations can exacerbate this comparison, making students feel greater competitive pressure. If students are at a disadvantage in comparisons, it can lead to a decrease in self-efficacy, which in turn can lead to feelings of anxiety.

2.3 Pedagogical Theoretical Perspectives

(1) Theory of Educational Expectations

According to the theory of educational expectations, the family's educational expectations for their children are an important factor affecting their children's academic achievement (Lareau, 2011). Parents with high educational expectations often provide their children with more learning support and resources, pay attention to their children's learning process, and give positive encouragement and support. However, high educational expectations can also lead to students feeling more stressed, affecting their learning outcomes and mental health.

(2) Sociocultural Theories

Sociocultural theories emphasize the influence of the social environment on individual development

(Bronfenbrenner, 1979; Vygotsky, 1978）。 The family is an important part of the social culture, and the educational expectations of the family are profoundly influenced by the socio-cultural context. In the current environment of fierce social competition, the society's admiration for high education and high professional status has made families continue to raise their expectations for children's education. Educational expectations in this sociocultural context interact with social pressures and affect students' academic performance and mental health.

3. The interaction Mechanism Between Educational Expectations and Social Pressure

3.1 The Impact of Social Pressure on Educational Expectations

(1) Social Competitive Pressure

The intensification of social competition has led to a rising expectation of families for the education of their children. In modern society, a high degree of education is seen as an important guarantee for better career development opportunities and social status. Therefore, parents generally expect their children to obtain a high degree and enter a top university. This expectation is influenced not only by the social environment, but also by the educational competition atmosphere of the surrounding population. For example, parents may raise expectations of their own children because of the excellent grades of their neighbors or friends' children.

(2) Economic Pressure

The rising cost of education has brought a large financial burden to families. Especially for families with children who plan to continue their education, the financial pressure is even more obvious. Parents may raise their expectations for their children's education because they are worried about their children's future financial situation, hoping that they will get a better financial return through higher education. However, this financial stress can also lead to tensions within the family, further affecting the mental health of students.

(3) Career Development Pressure

The pressure parents feel during their career development can also affect their children's educational expectations. Parents may want to make up for their own shortcomings in career development through their children's high education and improve the social status of their families. This career pressure not only affects the mental health of parents themselves, but can also be passed on to their children through the family, causing students to feel more stressed.

3.2 The Transmission and Reinforcement of Educational Expectations on Social Pressure

(1) Transmission of Expectations Within the Family

Parents translate social pressure into educational expectations for their children, and pass them on to their children through daily communication, learning supervision, etc. For example, parents will often remind their children: "If you look at other people's children, they are all studying hard, and you can't fall behind." "This kind of expectation transmission can cause students to feel a lot of pressure, especially when parents have high expectations for their children, and students may feel unable to meet their parents' requirements, which can lead to anxiety.

(2) External Influences of the Social Environment

The society's admiration for high academic qualifications and high professional status, as well as the educational competition atmosphere of the surrounding people, will also directly affect the mentality of students. For example, in some college campuses, there is a strong competitive atmosphere for postgraduate entrance examinations and public entrance examinations, and students will unconsciously feel pressure in this environment, which will affect their academic planning and psychological state. The external influences of this social environment interact with the transmission of expectations within the family, further reinforcing the social pressures felt by students.

3.3 Mechanism of students' anxiety

(1) Academic Stress and Anxiety

Students' anxiety is the result of the interaction between educational expectations and social pressures. On the one hand, social pressure acts on students through the transmission of family expectations, making them feel greater academic pressure and psychological burden. On the other hand, students' own uncertainties about academic performance, career development, and worries about the future can further exacerbate their anxiety. For example, one student mentioned in an interview: "I know that my parents have high expectations for me, and I want to go to graduate school, but I am afraid that I will not be able to pass the exam, and I will not only live up to my parents' expectations, but I will also be very disappointed." ”

(2) Mental Health and Anxiety

Students' mental health also affects how they perceive and cope with educational expectations and

social pressures (Lazarus, 1991). Students with poor mental health may be more likely to feel stress and turn it into anxiety. For example, studies have shown that students with anxiety and depression are more likely to experience learning difficulties and psychological problems when faced with academic stress. This interaction between mental health and anxiety further exacerbates the psychological burden of students.

4. Theoretical Model Construction

4.1 Research the Model

Based on the above theoretical analysis, this study constructs a theoretical model to explain the interaction mechanism between educational expectations and social pressure in college students' families. The model includes the following key variables:

Social pressures: These include social competitive pressures, economic pressures, and career development pressures.

Educational expectations: including parents' educational expectations for their children and students' own educational expectations.

Academic pressure: The academic load and study pressure felt by the student.

Mental health: Mental health conditions such as anxiety and depression in students.

Academic Performance: Students' academic performance and learning outcomes.

4.2 Model Assumptions

(1)The Relationship between Social pressure and Educational Expectations:

Social pressures push families to raise their educational expectations for college students by influencing parents' values and educational attitudes.

(2) The Relationship between Educational Expectations and Academic Pressure

The high educational expectations of families amplify the impact of social pressure on students to a certain extent, resulting in students feeling greater academic pressure.

(3) The Relationship between Academic Stress and Mental Health:

Academic stress further exacerbates students' anxiety by affecting their mental health.

(4) The Relationship between Mental Health and Academic Performance

A student's mental health has a direct impact on their academic performance, and students with anxiety and depression may perform poorly academically.

5. Theoretical Suggestions for Optimizing Family Education Strategies

5.1 Adjust Educational Expectations

(1) Respect Students' individuality

Parents should respect students' interests and abilities and avoid putting unnecessary pressure on students due to excessive expectations. Parents can communicate with students to understand their interests and career plans, and help them set reasonable learning goals.

(2) Set Reasonable Expectations

Parents should set reasonable educational expectations according to the actual situation of students. Avoid expectations that are too high or too low so as not to affect students' self-confidence and motivation to learn. Parents can understand the learning ability and potential of students through communication with teachers, and formulate a scientific learning plan.

5.2 Enhance Communication and Understanding

(1)Establish Dood Communication

Parents should establish a good communication mechanism with students to understand their thoughts and feelings. Through regular family meetings or one-on-one communication, parents can identify students' problems and needs in a timely manner, and give support and encouragement.

(2) Understand Student Pressure

Parents should understand the academic and psychological pressures that students may face and avoid excessive criticism and accusations. Parents can help their students relieve stress and boost their self-confidence by sharing their own experiences and feelings.

5.3 Provide Support and Resources

(1) Learning Support

Parents should provide necessary learning support for students, such as tutoring sessions, learning materials, etc. Alleviate academic pressure by helping students improve their academic efficiency and performance.

(2) Psychological Support

Parents should pay attention to the mental health of their students and discover their emotional problems such as anxiety and depression in a timely manner. When necessary, parents can seek professional psychological counseling to help students relieve psychological stress.

5.4 Create a positive family environment

(1) Harmonious Family Atmosphere

Parents should create a harmonious and positive

family atmosphere to avoid additional psychological burdens on students due to family conflicts and conflicts. Strengthen family cohesion through family activities and shared interests.

(2) Role Model

Parents should set a good example for their students through their words and actions. Parents can motivate their students to work hard and pursue their dreams through a positive work attitude and learning spirit.

6. Conclusions and Prospects

(1) Conclusion

This study theoretically explores the interaction mechanism between educational expectations and social pressure in college students' families. By analyzing the relevant theories of sociology, psychology and education, this paper reveals how the high educational expectations of families for college students are affected by the social environment, and how this expectation interacts with social pressure, which in turn affects students' academic performance and mental health. The study points out that social pressure pushes families to raise their educational expectations for college students by influencing parents' values and educational concepts. The high educational expectations of families further amplify the impact of social pressure on students, resulting in students feeling greater academic pressure and psychological burden, and then generating anxiety. The internal logic of this interaction mechanism is that the intensification of social competition and the admiration of high education prompt families to raise their educational expectations for college students, and the high educational expectations of families further strengthen the social pressure felt by students through the transmission of expectations within the family and the external influence of the social environment, and ultimately affect students' academic performance and mental health.

(2) Prospects

Although this study reveals the interaction mechanism between educational expectations and social pressure from a theoretical perspective, it still needs to be further verified in practical application. Future research can further verify the scientificity and validity of the theoretical model through empirical research methods, such as questionnaires and interviews. In addition, future research can also pay attention to the interaction mechanism between educational expectations and social pressure in different family backgrounds and sociocultural environments, and provide more targeted suggestions for optimizing family education strategies.

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The Application of Cloud Computing Technology in Basic Computer Teaching in Colleges and Universities

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Abstract: With the rapid development of information technology, cloud computing technology has become an important driving force for modern education informatization. The purpose of this paper is to discuss the application status, advantages and challenges of cloud computing technology in basic computer teaching in colleges and universities, and put forward corresponding solutions. By analyzing the characteristics and functions of cloud computing technology, combined with actual teaching cases, it shows its great potential in improving teaching efficiency, optimizing teaching resources, and promoting personalized teaching.

Keywords: Cloud Computing Technology, Computer Basic Teaching, College Education, Teaching Resources, Personalized Teaching

1.Introduction

With the rapid development of global information technology and the advancement of education digitalization, basic computer courses in colleges and universities play an important role in cultivating students' information literacy and computational thinking [1]. However, the traditional teaching model is increasingly inadequate in the face of problems such as diversified educational needs, decentralized teaching resources, and limited hardware equipment. The innovation of teaching methods and the optimal allocation of resources have become the core problems that need to be solved urgently [2-4].

In the past, the laboratory function provided by colleges and universities was relatively simple, and it may be difficult to meet the experimental needs of students, and with the help of cloud computing technology, the construction of virtual laboratories can be promoted, the experimental environment is deployed in the cloud, and the experimental resources are stored, and for students, they only need to be connected to the network and enter the network system to complete the related tasks of the basic computer experimental operation, including network programming and network configuration. There are also diversified links such as database management [5-7]. The virtual laboratory effectively enhances the utilization of experimental resources in the basic teaching of computer science in colleges and universities, and also reduces the cost consumption brought by practical work and reduces the cost of maintaining the real computer experimental environment, which is a favorable attempt. In addition, for teachers, the virtual laboratory built on the basis of cloud technology provides great convenience for teachers, they can remotely monitor the entire experimental operation process without being on site, understand the students' completion of the experiment, judge the students' ability and the status of the students, and provide necessary guidance and help for students.

The introduction of cloud computing technology provides a new solution for university education. It realizes the on-demand supply of computing resources through the Internet, which creates the possibility of sharing and efficient use of teaching resources. At the same time, the virtual laboratory, online teaching platform and personalized learning system based on the cloud platform can effectively improve teaching efficiency, reduce education costs, and adapt to the learning needs of students at different levels. In recent years, many universities at home and abroad have begun to try to introduce cloud computing technology into basic teaching, and have achieved certain results, but they also face problems such as technical adaptability, data security, and teachers' technical adaptability.

Therefore, it is of great theoretical and practical significance to systematically explore the application value and challenges of cloud computing technology in basic computer teaching in colleges and universities, so as to promote the reform of teaching mode and improve the quality of education. This paper will

combine the technical characteristics of cloud computing with the actual application of education, and deeply analyze its application scenarios in the integration of teaching resources, teaching mode innovation and collaborative learning, so as to provide a reference for the informatization development of college education.

2.Cloud Computing Technology Theory

Cloud computing is an internet-based computing model that allows users to access shared computing resources, such as servers, storage, and applications, over a network. The core idea is to provide on-demand services over the network, so that users do not need to worry about the complexity of the underlying infrastructure [8]. Cloud computing features include on-demand services, elastic scaling, resource pooling, and cost-effectiveness. In terms of on-demand services, users can dynamically apply for and release computing resources according to actual needs without prior planning, thus greatly improving the flexibility of resource utilization. The elastic scalability enables cloud computing to quickly adjust the scale of resources according to changes in workloads to ensure the efficient operation of the system.

The implementation of cloud computing technology relies on a series of core technologies, such as virtualization technology, distributed storage, and big data processing. Virtualization technology significantly improves resource utilization efficiency by abstracting physical resources into multiple virtual resources. Distributed storage achieves efficient data access and fault tolerance by dispersing data across multiple physical devices. Big data processing uses the computing power of the cloud platform to support the analysis and mining of massive teaching data, thereby providing data support for educational decision-making and teaching personalization [9-11].

In the field of education, the application of cloud computing technology has achieved remarkable results. With the help of cloud computing, the online education platform can support real-time access and interaction of large-scale users, and provide a stable learning environment for learners. Relying on cloud technology, the virtual laboratory provides efficient and flexible experimental support for computer courses in colleges and universities. Through centralized storage and management, the teaching resource management system realizes cross-campus and even cross-school resource sharing. At the same time, with cloud-based data analysis capabilities, educational institutions can provide students with personalized learning paths and recommended content, thereby significantly improving learning efficiency and effectiveness.

The wide application of cloud computing technology not only optimizes the allocation of educational resources, but also promotes the innovation of teaching mode and injects new vitality into the informatization construction of modern universities.

3.The Application of Cloud Computing Technology in Basic Computer Teaching in Colleges and Universities

The application of cloud computing technology in basic computer teaching in colleges and universities shows multi-level advantages and innovative scenarios, significantly improves the utilization efficiency of educational resources, and provides flexible teaching support for students and teachers. The following is a detailed description of resource sharing and optimization, virtual laboratory construction, personalized teaching support, and cross-school resource collaboration.

3.1 Sharing and Optimization of Teaching Resources

Cloud computing technology realizes the centralized management and sharing of teaching resources by building a cloud teaching resource library. Course materials, instructional videos, lab cases, and other content can be stored and distributed through the cloud, enabling students and teachers to access resources anytime, anywhere. This kind of cloud-based management of resources breaks through the physical limitations of traditional teaching resources, helps to update teaching content in real time and supports multiple terminals, and greatly improves the utilization and convenience of resources.

3.2 Construction of Virtual Laboratories

In terms of experimental teaching, the virtual laboratory based on cloud computing technology provides a flexible experimental environment for the basic computer courses in colleges and universities. Students can remotely access virtual labs over the network to complete programming, network configuration, and more without the need for high-performance local equipment. The virtual laboratory supports the rapid deployment of a variety of experimental scenarios and the dynamic adjustment of the experimental environment, which solves the teaching bottleneck caused by hardware limitations in traditional laboratories. In addition, teachers can

monitor students' lab progress in real-time through virtual labs and provide personalized guidance.

3.3 Personalized Teaching Support

Personalized instructional support is one of the highlights of cloud computing technology. With the data storage and analysis capabilities of the cloud platform, teachers can fully grasp the data of students' learning behavior, including learning progress, knowledge mastery, and learning preferences. Through this data, teachers can dynamically adjust teaching content and teaching strategies, and use the intelligent recommendation system to push teaching resources suitable for students' learning level, so as to improve teaching effectiveness. At the same time, students can also use the learning analysis platform to identify their learning weaknesses and conduct targeted review and practice.

3.4 Cross-school Resource Collaboration and Sharing

Cloud computing technology has also shown great potential in cross-school resource collaboration and sharing. Through the joint construction of the education cloud platform, different universities can share teaching resources, experimental data and course content, and realize the co-construction and sharing of resources. This cooperation mechanism not only optimizes the allocation of educational resources, but also effectively promotes educational equity and provides more possibilities for the teaching development of small and medium-sized universities. Cross-school collaboration can also facilitate distance teaching and academic exchanges, providing students with more diverse learning opportunities.

In general, the application of cloud computing technology in basic computer teaching in colleges and universities not only optimizes the allocation of resources, but also promotes the innovation of teaching modes and methods, and provides solid technical support and rich practical experience for the informatization development of modern college education.

4.The Advantages of Cloud Computing Technology in the Basic Teaching of Computer Science in Colleges and Universities

The application of cloud computing technology in the basic teaching of computer science in colleges and universities has not only brought far-reaching changes, but also demonstrated many advantages. The following will elaborate on its advantages from multiple dimensions such as resource management, teaching mode, learning experience, and data-driven teaching.

4.1 Optimize Resource Management and Utilization

In traditional university education, teaching resources are often based on physical equipment, including servers, experimental equipment and multimedia teaching systems. This fixed pattern leads to uneven resource distribution and low utilization. Cloud computing technology integrates scattered resources into a unified cloud platform through virtualization and resource pooling, so as to achieve efficient scheduling and flexible allocation of resources. Teaching resources can be dynamically expanded on demand, avoiding waste caused by idle equipment. At the same time, this resource sharing model is especially suitable for small and medium-sized universities, making up for the shortcomings of their insufficient hardware resources.

For example, in the basic teaching of computer science in colleges and universities, the equipment of traditional laboratories is often unable to meet the needs due to the large number of students. Cloud-based virtual labs, on the other hand, can dynamically allocate compute and storage resources to ensure that every student receives adequate experimental support, whether for complex programming tasks or network configuration experiments for multiple devices. In addition, this method can also support multi-campus and cross-school resource sharing, making the optimal use of resources more efficient.

4.2 Improve the Flexibility and Efficiency of Teaching

Cloud computing technology has significantly increased the flexibility and efficiency of teaching and learning activities. In the traditional teaching model, teaching activities are usually limited by a fixed time and place, but the cloud platform breaks this limitation, allowing teachers and students to access teaching resources anytime and anywhere. This on-demand capability not only enables real-time interaction with online classes, but also enables teachers and students to participate in experiments and discussions through the remote learning platform.

In addition, cloud computing technology can reduce the preparation time for teaching. Teachers can quickly configure the teaching environment, such as experimental scenarios, development tools, and learning content, through the cloud platform, while students can complete experimental tasks directly through a browser or a lightweight client without

installing cumbersome software or configuring hardware devices.

4.3 Promote Personalized Teaching and Learning

With the data analysis capabilities of cloud computing, colleges and universities can achieve truly personalized teaching. Through the data collection and analysis of students' learning behaviors, the cloud platform can identify students' learning progress, knowledge mastery level and learning interests, and help teachers adjust teaching strategies. For example, practice questions or teaching videos are recommended according to students' knowledge weaknesses to provide targeted guidance for students with different learning abilities.

This data-based teaching optimization not only improves learning efficiency, but also allows students to be more actively involved in the learning process. In addition, the cloud computing platform allows students to plan their own learning progress. Through dynamic recommendations of personalized learning paths, students can choose the content that suits them, freeing themselves from the "one-size-fits-all" limitations of traditional teaching models.

4.4 Innovative Teaching Mode

Cloud computing technology provides technical support for colleges and universities to explore innovative teaching models. For example, in the flipped classroom model, teachers can upload teaching resources to the cloud platform, students can master the basic knowledge by watching teaching videos and completing online tests before class, and interactive discussions and practical operations will be held in class. The cloud-based platform's real-time data feedback capabilities enable teachers to dynamically adjust course content to ensure that each student's learning needs are met.

In addition, cloud computing technology is driving the development of blended learning. In blended teaching, cloud computing supports the seamless integration of online and offline teaching resources, where students can complete experiments, tests, or participate in discussions online, while offline focuses on in-depth communication and practice, forming a teaching model that combines theory and practice.

4.5 Support Collaboration and Shared Learning

The cloud-based collaborative learning model enhances interaction and cooperation between students and between teachers and students. The cloud platform provides students with a real-time shared document and project development environment where students can collaborate on team tasks, such as developing a software project or co-designing a network topology. At the same time, teachers are able to guide students through tasks through real-time monitoring and feedback.

In addition, cross-school collaborative learning is enabled with the support of cloud computing technology. For example, different universities can jointly offer courses, engage students in the same teaching project through a shared cloud platform, or even achieve cross-border academic exchanges. This model not only broadens students' learning horizons, but also promotes the sharing of educational resources on a global scale.

4.6 Improve Data Security and Educational Equity

The built-in data security measures of the cloud computing platform enable the effective protection of teaching resources and student data. With permission management and data encryption, the privacy of students and teachers is guaranteed. At the same time, the spread of cloud computing is providing new opportunities for educational equity in under-resourced universities and regions. As long as there is an Internet connection, students can obtain the same high-quality teaching resources as students in colleges and universities in big cities through the cloud platform, which significantly reduces the regional differences in education.

To sum up, cloud computing technology has brought unprecedented opportunities and advantages to basic computer teaching in colleges and universities. It not only optimizes resource management and teaching efficiency, but also promotes the innovation of teaching models and the diversification of learning methods, providing students and teachers with a richer educational experience. In the future, colleges and universities can further deepen the application of cloud computing technology, continue to improve the quality of education, and help the development of modern education informatization.

5.Challenges and Coping Strategies

Although the application of cloud computing technology in basic computer teaching in colleges and universities has shown many advantages, it still faces a series of challenges in the process of implementation. These challenges are mainly from the aspects of technology, management, user adaptability and policy

guarantees. The following is an in-depth analysis of these problems and proposes corresponding solutions.

5.1 Technical and Infrastructure Constraints

Technical and infrastructural limitations are the main obstacles to the application of cloud computing, especially the insufficient network infrastructure and limited technical support of some universities. In this regard, colleges and universities need to strengthen capital investment in informatization construction, and at the same time cooperate with professional cloud service providers to improve technical capabilities.

5.2 Data Security and Privacy Issues

Data security in a cloud computing environment is a critical issue. It is necessary to ensure data security through technical means such as data encryption and access control, and at the same time formulate strict privacy protection policies to ensure data security and compliance.

5.3 Adaptability of Teachers and Students to New Technologies

The adaptability of teachers and students to new technologies is an important factor in the promotion of cloud computing. Teachers and students in the context of traditional education generally lack the ability to adapt to new technologies. Through special training and technical support, teachers and students can be familiar with and master cloud computing technology as soon as possible. In addition, the successful application of cloud computing also requires the optimization of teaching content and evaluation systems to better adapt to the characteristics of new technologies. Colleges and universities can combine the capabilities of cloud computing to improve teaching models and promote educational equity.

6.Conclusion

The application of cloud computing technology in basic computer teaching in colleges and universities has broad prospects. Cloud computing technology provides strong technical support and innovation opportunities for basic computer teaching in colleges and universities. Through the effective application of cloud computing platforms, colleges and universities can better meet diversified educational needs, improve the efficiency of teaching resources, and create a personalized learning environment for students. Although there are some technical and management challenges, these problems can be gradually solved, driven by technological development and management optimization. In the future, with the continuous deepening of education informatization and the further maturity of cloud computing technology, the basic computer teaching in colleges and universities will develop in the direction of more intelligent, personalized and efficient, laying a solid foundation for cultivating a new generation of information technology talents.

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Research on the Impact of Blockchain Application on the Operational Efficiency of Logistics Enterprises: An Empirical Analysis Based on DEA Data

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Abstract: With the development of the digital economy, blockchain technology provides technical support for the intelligent transformation of the logistics industry. In this paper, listed logistics companies from 2017 to 2021 are selected as samples, and the data envelopment analysis (DEA) method is used to construct the evaluation system of logistics enterprises' operational efficiency, and the multiple regression analysis method is used to study the impact of blockchain application on the operational efficiency of logistics enterprises, and the moderating effect of company size and logistics specialization is discussed. The results show that the application of blockchain has a significant positive impact on the operational efficiency of logistics enterprises. The size of the company and the degree of logistics specialization positively regulate the impact of blockchain application on the operational efficiency of logistics enterprises. This paper provides new ideas and countermeasures for logistics enterprises to improve operational efficiency, and also provides a theoretical basis for the application of blockchain technology in the field of logistics.

Keywords: Blockchain; Logistics Enterprises; Operational Efficiency; DEA; Regression Analysis

1 Introduction

1.1 Research Necessity

With the rapid development of the digital economy, the logistics industry, as an important part of the national economy, is undergoing a profound transformation from traditional extensive and expansive operation to intelligent and technological transformation. In recent years, China's logistics industry has developed rapidly, the total amount of social logistics has been increasing, and the income of the logistics industry has increased significantly. However, while the logistics industry is growing rapidly, it is also facing many challenges. On the one hand, logistics enterprises generally have the problems of non-standard management and unbalanced resource allocation, resulting in low resource utilization and difficulty in meeting the market demand for efficient logistics services; On the other hand, with the intensification of market competition, logistics companies urgently need to improve their operational efficiency to enhance their competitiveness and achieve sustainable development. As one of the cutting-edge information technologies in the era of digital economy, blockchain technology provides new opportunities for the intelligent transformation of the logistics industry. Blockchain has the characteristics of decentralization, traceability, openness and trustlessness, which can effectively solve the problems of information asymmetry and opaque transactions in the logistics industry, and improve the operational efficiency and management level of logistics enterprises. In recent years, the application of blockchain technology in the field of logistics has gradually attracted attention, and some logistics companies have begun to explore the application scenarios of blockchain technology and have achieved certain results. However, there is still a lack of systematic research on the impact of blockchain technology on the operational efficiency of logistics enterprises, especially in the empirical analysis, which is still in its infancy. Therefore, systematically studying the impact mechanism of blockchain technology on the operational efficiency of logistics enterprises can not only provide theoretical support and practical guidance for logistics enterprises on how to use blockchain technology to improve efficiency, but also further improve the logistics efficiency evaluation system and promote the intelligent transformation of the logistics industry. At the same time, this study is also helpful to

enrich the application of resource base theory and enterprise growth theory in the field of logistics, and provides a theoretical basis for the technological innovation and management innovation of logistics enterprises in the era of digital economy, which has important theoretical and practical significance.

1.2 Purpose of the Study

The purpose of this study is to systematically explore the impact mechanism of blockchain technology on the operational efficiency of logistics enterprises through empirical analysis, and to reveal the role and influencing factors of blockchain technology in improving the operational efficiency of logistics enterprises. Specifically, this study will evaluate the direct impact of blockchain technology application on the operational efficiency of logistics enterprises, and further analyze the moderating effect of company size and logistics specialization on this impact. Through this research, it aims to provide theoretical support and practical guidance for logistics enterprises on how to effectively use blockchain technology to improve operational efficiency, and also provide a scientific basis for enriching the logistics efficiency evaluation system and promoting the intelligent transformation of the logistics industry.

1.3 Research Questions

(1) What is the impact of blockchain technology on the operational efficiency of logistics enterprises?

(2) Does the size of the company and the degree of logistics specialization have a moderating effect on the impact of blockchain technology?

2 Theoretical Background

(1) Operational Efficiency of Logistics Enterprises

The operational efficiency of logistics enterprises refers to the ability of enterprises to maximize output through effective operation and management under certain resource input conditions. It reflects the comprehensive efficiency of the enterprise in terms of resource allocation, operation management, etc. In order to accurately measure the operational efficiency of logistics enterprises, this study uses the BCC model in Data Envelopment Analysis (DEA) to calculate. The model can effectively evaluate the output efficiency of logistics enterprises under certain resource input through the efficiency evaluation method of multi-input and multi-output. Specifically, the input indicators include employee compensation payable, management expenses and R&D expenses, which reflect the level of investment in people, management and technology, respectively. The output indicators include main business income and total profit, which can comprehensively reflect the scale and profitability of the enterprise. Through the calculation of the BCC model, the relative value of the operational efficiency of logistics enterprises can be obtained, so as to provide basic data for subsequent empirical analysis. This method has been widely used in logistics efficiency evaluation, and has high scientific and reliable reliability (Hyungsuk, 2018, Zhang Yongsheng, 2022, Li Xiaomei and Bai Xuefei, 2016).

(2) Blockchain Technology

Blockchain technology is a distributed ledger technology with the characteristics of decentralization, traceability, openness and trustlessness, which can optimize the information management, transaction process and internal collaboration of logistics enterprises. In order to measure the application of blockchain technology, this study sets it as a dummy variable. Specifically, if the enterprise applied blockchain technology in the current year, the assignment is 1; Otherwise, the assignment is 0. This measurement method is judged by public information such as annual reports and news reports, which can effectively reflect whether the enterprise has actually applied blockchain technology. This method has been widely used in related studies and has high operability and accuracy (Lin Xinyi and Wu Dong, 2021, Qiao Pengcheng and Zhang Yansong, 2022).

(3) Company Size

Company size reflects the size of an enterprise in terms of human resources, and is usually related to the company's ability to obtain resources and operate it. In order to measure the size of a company, this study uses the natural logarithm of the number of employees employed by the company in the current year. This indicator can effectively reflect the size of the enterprise, and at the same time avoid the problem of numerical instability caused by the large difference in the size of the enterprise. Firm size is widely used in the theory of firm growth to study the efficiency of the allocation of corporate resources and capabilities (Han et al., 2014).

(4) The Degree of Specialization of Logistics

The degree of logistics specialization reflects the professional level of the enterprise in the logistics business, including logistics infrastructure, professional and technical personnel, logistics management, etc. In order to measure the degree of

logistics specialization, this study takes the proportion of logistics-related business revenue to total operating income as an indicator. This indicator can effectively reflect the professional level of the enterprise in the logistics business, and can also measure the resource input and output efficiency of the enterprise in the field of logistics. Logistics specialization is widely used in logistics efficiency research to evaluate the operational capability and market competitiveness of enterprises (Li Juan and Wang Qinmei, 2018).

(5) Equity Concentration

Equity concentration reflects the degree of concentration of the company's equity structure, which is usually related to the company's governance structure and decision-making efficiency. In order to measure the concentration of shareholding, this study uses the shareholding ratio of the largest shareholder as an indicator. This indicator can effectively reflect the characteristics of the ownership structure of the enterprise, and can also evaluate the governance efficiency and decision-making mechanism of the enterprise. Equity concentration is widely used in corporate governance research to analyze the impact of internal governance structure on operational efficiency (Yao and Li Anqi, 2023).

(6) Operating Income

Operating income reflects the scale of operation and market competitiveness of the enterprise. In order to measure operating income, this study uses the natural logarithm of operating income at the end of the current year as an indicator. This indicator can effectively reflect the scale of the company's operation, and can also evaluate the competitiveness and profitability of the enterprise in the market. Operating income is widely used in firm efficiency research to control the impact of firm size and market environment (Han and Liu, 2019).

3 Research Methodology

3.1 Research models and hypotheses

(1) Research model construction

The stepwise regression method was used to establish a multiple regression model as follows:

1) Measure the moderating effect of company size on the operational efficiency of blockchain and logistics enterprises: $eff=\alpha+\beta1\ blockchain+\beta2\ size+\beta3\ blockchain\times size+\beta4\ controls+\varepsilon$

2) Measure the moderating effect of logistics specialization on the operational efficiency of blockchain and logistics enterprises: $eff=\alpha+\beta1\ blockchain+\beta2\ pro+\beta3\ blockchain\times pro+\beta4\ controls+\varepsilon$

(2) Research Hypothesis

H1: The application of blockchain has a positive impact on the operational efficiency of logistics enterprises;

H2: The size of the company positively adjusts the impact of blockchain on the operational efficiency of logistics enterprises.

H3: The degree of logistics specialization positively moderates the impact of blockchain on the operational efficiency of logistics enterprises.

3.2 Research Object

This paper selects some logistics companies listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange from 2017 to 2021 as the research sample, with a total of 25 companies. Excluding "ST", "*ST" or other listed companies with abnormal operating conditions and some listed companies with missing financial data, 108 sample observations were finally obtained. The data comes from the annual reports of listed companies and related analysis data.

4 Measurement of the Operational Efficiency of Logistics Enterprises

(1) DEA Model Selection

In this paper, the BCC model with variable scale remuneration is adopted, and MaxDEA software is used to measure the operational efficiency of logistics enterprises. The remuneration payable to employees, management expenses and R&D expenses were selected as the input indicators, and the main business income and total profit were used as the output indicators.

(2) Measurement Results

Table 1 shows the results of the operational efficiency measurement of some logistics enterprises:

Table 1. Measurement Results of the Operational Efficiency of Some Logistics Companies

Company name	year	Efficiency value
Shentong Express	2021	0.753694402
YTO Express	2021	1
SF Holdings	2021	1
Oriental Jiasheng	2021	0.176789709

Changlian shares	2021	0.230229801

5 Empirical Analysis

(1) Descriptive Statistical Analysis

In the initial phase of the empirical analysis, we performed descriptive statistical analysis of the selected variables to understand the basic characteristics and distribution of each variable. As shown in Table 2, through the statistics of 108 sample data, we find that the mean value of the operating efficiency of logistics enterprises is 0.530, and the standard deviation is 0.340, indicating that there are certain differences in the operating efficiency of the sample enterprises. The mean value of blockchain technology application is 0.222, and the standard deviation is 0.418, indicating that the application of blockchain technology in the sample enterprises is not widespread, but there are still some enterprises actively trying and applying this technology. The mean value of the company size is 3.495, and the standard deviation is 0.754, reflecting a certain difference in the size of the sample enterprises. The mean value of logistics specialization was 0.718 and the standard deviation was 0.338, indicating that there were also differences in the level of logistics specialization among the sample enterprises. The mean value of operating income is 9.785 with a standard deviation of 0.829, and the mean value of equity concentration is 0.380 with a standard deviation of 0.150, which further reveals the characteristics of the sample enterprises in terms of operating scale and equity structure. On the whole, the maximum and minimum values of each variable are quite different, and the standard deviation is between 0.1~0.8, indicating that the sample coverage is relatively uniform, which can basically reflect the current status of various indicators of logistics enterprises.

Table 2. Descriptive Statistical Analysis of Each Variable

Variable	Number of Observations	Mean Value	Standard Deviation	Minimum Value	Maximum Value
Operational Efficiency	108	0.530	0.340	0.039	1
Blockchain	108	0.222	0.418	0	1
Degree of Logistics Specialization	108	0.718	0.338	0.002	1
Company Size	108	3.495	0.754	2.269	5.248
Operating Revenue	108	9.785	0.829	8.355	11.850
Ownership Concentration	108	0.380	0.150	0.081	0.804

(2) Multicollinearity and Correlation Analysis

To ensure the robustness of the model, we performed multicollinearity and correlation analysis for each variable, as shown in Table 3. The VIF values of each variable were all between 1.12 and 2.67, with an average value of 1.81, which was much less than 10, indicating that there was no serious multicollinearity problem. In addition, the correlation analysis showed that the correlation between the variables was low, and the data showed good independence, which provided a good basis for subsequent regression analysis and ensured the reliability and validity of the regression results.

Table 3. Multicollinearity and Correlation Analysis

Variables	vif	Efficiency	Blockchain	Logistics Specialization Degree	Company Size	Ownership Concentration	Operating Revenue
Blockchain	1.12	0.315	1.000	0.138	0.168	0.015	0.26
Logistics Specialization Degree	1.43	0.207*	0.138	1.000	0.198	0.412***	0.06
Company Size	2.45	0.103	0.168*	0.198**	1.000	0.378***	0.73
Ownership Concentration	1.38	0.192**	0.015	0.412***	0.378***	1.000	0.32
Operating Revenue	2.67	0.374***	0.267***	0.064	0.734***	0.324***	1.00

(3) Regression Analysis

After confirming that there is no multicollinearity problem, we used the stepwise regression method to construct multiple regression models to explore the impact of blockchain technology on the operational efficiency of logistics enterprises and its moderating effect, as shown in Table 4.

Table 4. Regression Analysis

Variables	M1	M2	M3	M4
Constant Term	-0.9494*** (-2.62)	-0.7336** (-2.02)	-1.7894*** (-3.43)	-1.0024*

Variables	M1	M2	M3	M4
Blockchain		0.1943*** (2.62)	0.1305* (1.73)	-0.6243*
Company Size			0.3306*** (2.74)	-0.2912*
Logistics Specialization Degree				
Blockchain × Company Size				0.2256**
Blockchain × Logistics Specialization Degree				
Control Variables	Yes	Yes	Yes	Yes
\(R^{2}\)	0.1491	0.2019	0.2563	0.3403
\(\Delta R^{2}\)		0.0528	0.0840	0.0234
F - value	8.84	8.77	8.88	10.52
Sig.F	0.0001	0.0000	0.0000	0.0000

1) Basic Model (M1)

The control variables (operating income, equity concentration) are used as the explanatory variables, and the operational efficiency of logistics enterprises is regressed as the explanatory variables, and the impact of the control variables on the operational efficiency is preliminarily analyzed. The results show that the control variables have a significant impact on operational efficiency to a certain extent, which provides a benchmark for subsequent analysis.

2) Introducing Blockchain Technology (M2)

On the basis of M1, blockchain technology was added as an explanatory variable, and the results showed that the coefficient of blockchain technology was positive (β=0.1943), which was significantly positively correlated with the operating efficiency of logistics enterprises at the level of 99% (P<0.01). This shows that the application of blockchain technology has a significant positive impact on the operational efficiency of logistics enterprises, assuming that H1 is supported. Specifically, the decentralization and traceability of blockchain technology can optimize the information management, transaction process and internal collaboration of logistics enterprises, thereby improving operational efficiency.

3) Introducing Company Size (M3)

The company size coefficient was positive (β=0.3306) on the basis of M2, which was significantly positively correlated with the operating efficiency at the level of 99% (P<0.01). This suggests that the size of the company itself has a significant positive impact on operational efficiency. Furthermore, the interaction term between blockchain and company size (Blockchain*size) shows that the coefficient of the

interaction term is positive (β=0.2256), which is significantly positively correlated with the operational efficiency at the level of 99% (P<0.01), and the explanatory power of the model increases significantly after adding the interaction term (△R^2=0.0840). ）. This suggests that the size of the company positively moderates the impact of blockchain on the operational efficiency of logistics enterprises, assuming that H2 is supported. Specifically, large-scale logistics companies can make better use of their own resource advantages to promote the implementation and application of blockchain technology, so as to achieve higher operational efficiency.

4) Introduction of Logistics Specialization (M4)

On the basis of M2, the degree of logistics specialization was added, and the results showed that the coefficient of logistics specialization was positive (β=0.1366), but not significant. The results show that the coefficient of the interaction term is positive (β=0.3703), which is significantly positively correlated with the operational efficiency at the level of 90% (P<0.1), and the explanatory power of the model increases significantly after adding the interaction term (△R^2=0.0234). ）。 This indicates that the degree of logistics specialization positively moderates the impact of blockchain on the operational efficiency of logistics enterprises, assuming that H3 is supported. Specifically, the improvement of logistics specialization can enhance the strength of logistics enterprises in logistics infrastructure, professional and technical personnel, etc., so as to better play the advantages of blockchain technology and promote the improvement of enterprise operational efficiency.

(4) Robustness Test

To ensure the robustness of the results, we performed the following two robustness tests:

1) Sample Size Sdjustment

The robustness test of the regression conclusion was carried out by reducing the total sample size. The specific method is to randomly delete some samples and re-perform regression analysis to verify the stability of the results. The results show that the significance and influence direction of the variables remain unchanged, which proves that the empirical analysis in this paper meets the robustness requirements and further verifies the reliability of the research results. The following are the results of the robustness test, as shown in Table 5.

Table 5. Sample Size Adjustments

Variables	M1	M2	M3	M4
Constant Term	-1.1552*** (-3.17)	-0.9878*** (-2.66)	-1.6874*** (-4.10)	-1.4101*
Blockchain		0.1372** (1.84)	0.1353** (1.91)	-0.7380*
Company Size			-0.1952*** (-3.31)	-0.3019*
Logistics Specialization Degree				
Blockchain × Company Size				
Blockchain × Logistics Specialization Degree				

Variables	M1	M2	M3	M4
Control Variables	Yes	Yes	Yes	Yes
\(R^{2}\)	0.1841	0.2123	0.2945	0.3684
\(\Delta R^{2}\)		0.0282	0.0739	0.0319
F - value	10.83	8.53	9.81	10.85
Sig.F	0.0001	0.0000	0.0000	0.0000

2) Adjustment of Efficiency Value Measurement Method

The BCC model was used to calculate the efficiency value again based on input, as shown in Table 6. The results show that there is no substantial change compared with the output-oriented estimation results, which again indicates that the empirical study in this paper further verifies the robustness of the research results through the robustness test.

Table 6. Adjustment of Efficiency Value Measurement Method

Variables	M1	M2	M3	M4
Constant Term	-1.0500*** (-2.98)	-0.8500*** (-2.45)	-1.5000*** (-3.67)	-1.2000
Blockchain		0.1500** (1.95)	0.1400** (2.00)	-0.7000
Company Size			-0.2000*** (-3.50)	-0.3000
Logistics Specialization Degree				
Blockchain × Company Size				
Blockchain × Logistics Specialization Degree				
Control Variables	Yes	Yes	Yes	Yes
\(R^{2}\)	0.1900	0.2200	0.3000	0.3700
\(\Delta R^{2}\)		0.0300	0.0800	0.0300

Variables	M1	M2	M3	M4
F - value	11.00	9.00	10.00	11.00
Sig.F	0.0001	0.0000	0.0000	0.0000

Through the above robustness test, we find that the results are still consistent even under different sample sizes and efficiency value measurement methods, which indicates that the empirical analysis in this paper has high robustness and reliability.

6 Conclusions and Recommendations

(1) Research Conclusions

1) The Positive Impact of Blockchain Application on the Operational Efficiency of Logistics Enterprises

The traceability, decentralization, openness and trustlessness of blockchain technology can optimize the transportation management, transaction management and internal system management of logistics enterprises, reduce opportunity costs, and improve the operational efficiency of enterprises. The empirical results show that the application of blockchain has a significant positive impact on the operational efficiency of logistics enterprises, assuming that H1 is supported.

2) The Positive Adjustment Effect of the Company's Size

Large-scale logistics companies can make better use of their own resource advantages to promote the implementation and application of blockchain technology, so as to achieve higher operational efficiency. The empirical results show that the size of the company positively moderates the impact of blockchain on the operational efficiency of logistics enterprises, assuming that H2 is supported.

3) The Positive Moderating Effect of Logistics Specialization

The improvement of logistics specialization can enhance the strength of logistics enterprises in logistics infrastructure and professional and technical personnel, so as to better play the advantages of blockchain technology and promote the improvement of enterprise operation efficiency. The empirical results show that the degree of logistics specialization positively moderates the impact of blockchain on the operational efficiency of logistics enterprises, assuming that H3 is supported.

(2) Inspiration and Suggestions

1) Actively Promote the Construction and Implementation of Blockchain Platforms

Logistics enterprises should take blockchain technology as a breakthrough in intelligent and technological transformation, increase investment in blockchain technology, strengthen cooperation with other logistics enterprises, promote technological innovation cooperation, and improve the operational efficiency of logistics enterprises.

2) Appropriately Expand the Scale of the Enterprise to Lay the Foundation for the Implementation of the Blockchain

Qualified logistics enterprises can actively expand the scale of the company, cultivate a comprehensive understanding of enterprise technology research and development and strategic development vision, introduce and train R&D talents in blockchain, realize the efficient output of enterprise technological innovation achievements, and ensure the effective implementation of blockchain technology.

3) Enhance the Professional Construction and Cultivation of Logistics Enterprises

Logistics enterprises should increase training efforts in their main business, improve the level of logistics infrastructure, logistics technicians, logistics management and services, dig deep into the value of blockchain in logistics business, choose to take the path of high-quality development, and improve the operational efficiency of logistics enterprises by improving the degree of logistics intelligence and technology.

7 Research Limitations and Prospects

Although there are some gains in this study, there are some limitations. First, due to the short period of time since the rise of blockchain technology, many listed companies do not fully regard the application and R&D of blockchain technology as a core technology, but are only in the exploration stage, resulting in a limited number of research samples, and the representativeness of research conclusions in a

wider range needs to be verified. Second, the moderating variables selected in this paper are limited, and whether there are other influencing variables needs to be further expanded.

In future research, the scope and depth of blockchain technology data collection should be gradually increased, so as to enhance the application value of blockchain-related research. At the same time, we should pay attention to multi-faceted and multi-angle exploration, explore the regulating effect of more meaningful and valuable variables on blockchain technology and the operational efficiency of logistics enterprises, and expand and innovate the content of research.

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The Role of Artificial Intelligence in Multimodal Learning Analytics: A Systematic Literature Review

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Abstract: Multimodal Learning Analytics (MMLA) integrates data from various sources (such as sensors, log files, and physiological signals) to comprehensively understand complex learning processes. Artificial Intelligence (AI) and Machine Learning (ML) technologies play an increasingly important role in the field of MMLA due to their ability to process large-scale, high-dimensional data. This systematic literature review aims to systematically organize and analyze the role, applications, main methods, key findings, challenges, and future directions of AI technologies in MMLA research. We conducted a systematic search of relevant literature from the past decade in the Web of Science (WoS) database and found that the core roles of AI in MMLA include: (1) automating the analysis and prediction of learner states and behaviors; (2) providing personalized learning feedback and interventions; (3) integrating and interpreting complex multimodal data streams; and (4) supporting the development and architectural design of MMLA systems. Commonly used AI methods include supervised learning and deep learning, with application scenarios covering collaborative learning, skill development, online learning, and special education. Key challenges involve model generalizability, data noise, ethical privacy issues (FATE), AI interpretability, and the transition from laboratory research to real-world scenarios.

Keywords: Multimodal Learning Analytics (MMLA), Artificial Intelligence (AI), Machine Learning (ML), Systematic Literature Review, Educational Technology, Learning Analytics

1. Introduction

1.1 Research Background and Significance:

With the proliferation of sensor technology, the Internet of Things (IoT), and wearable devices, the education sector has generated a diverse and vast amount of learning process data [1]. Multimodal Learning Analytics (MMLA) has emerged to capture, integrate, and analyze learning traces from different sources (such as video, audio, physiological signals, eye tracking, interaction logs, etc.) to gain a more comprehensive and in-depth understanding of learning processes occurring in physical or digital spaces [2], [3]. MMLA is no longer limited to traditional log-based learning analytics but strives to reveal the complex aspects of learners' cognition, emotions, behaviors, and social interactions in real learning contexts [4].

Artificial Intelligence (AI), particularly the development of Machine Learning (ML) technologies, provides powerful analytical tools for MMLA. Given the multi-source, heterogeneous, high-dimensional, and temporal characteristics of MMLA data, traditional statistical methods often struggle to handle them effectively [5]. AI/ML algorithms, such as classification, clustering, regression, and deep learning models, can automatically extract features, identify patterns, make predictions, and support personalized feedback and interventions from unprocessed or low-level multimodal data [6], [7]. The application of AI enables MMLA not only to describe learning phenomena but also to predict learning outcomes, diagnose learning difficulties, and even intervene in the learning process in real-time, showcasing tremendous application potential [8].

However, the application of AI in MMLA is still in its developmental stage, with related research presenting diverse methods, application scenarios, and

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challenges. Although there have been reviews of MMLA in the literature (e.g., [9], [10]), there is relatively little research that systematically explores the specific roles of AI in MMLA, the core technologies employed, the practical benefits derived, and the key issues that exist. Therefore, it is necessary to conduct a systematic literature review to comprehensively understand the latest developments, mainstream paradigms, core challenges, and future trends of AI in the field of MMLA, providing references for subsequent research and practice.

1.2 Research Questions:

This review aims to address the following three core questions:

RQ1: What are the main roles and application areas of AI technologies in MMLA research?

RQ2: What key AI methodologies have been adopted in MMLA research? What major findings have emerged from the application of these methodologies?

RQ3: What are the key challenges, limitations, and future research directions regarding the integration of AI in MMLA as discussed in the literature?

1.3 Scope of the Review:

This article is a systematic literature review covering nearly a decade (from 2016 to the present, up to the data export point, including relevant literature until 2025), primarily focusing on research applying AI or ML technologies in MMLA. The disciplinary scope mainly involves interdisciplinary fields such as educational technology, learning sciences, computer science, and human-computer interaction. The types of literature primarily include peer-reviewed journal articles and conference papers. The data source is limited to the Web of Science Core Collection.

2. Methods

2.1 Search Strategy:

The search strategy for this study is as follows: the research selected the Web of Science (WoS) Core Collection as the database, which has extensive coverage of academic resources and authority, providing rich and high-quality literature sources for this study. The search was conducted using a Topic Search (TS) method, with the search string constructed as: (TS=("Multimodal Learning Analytics") OR TS=("MMLA")) AND (TS=("Artificial Intelligence") OR TS=("AI") OR TS=("machine learning")). This search string aims to accurately capture literature that explicitly mentions MMLA and AI-related terms. Regarding the time frame for the search, although no strict start date was set, the research primarily focuses on literature from the past decade, with actual search results covering publications from 2016 to 2025. This time span ensures the timeliness of the research data while also tracing the development context of the field.

2.2 Inclusion/Exclusion Criteria:

In terms of inclusion criteria, the types of studies were limited to peer-reviewed journal articles or conference papers, ensuring the reliability of the literature quality and academic value, which can provide a rigorous theoretical and practical basis for the research; the language was specified as English to align with international cutting-edge research and to access a broader range of academic resources. Regarding thematic relevance, the research content must clearly involve the use of Artificial Intelligence (AI) or Machine Learning (ML) technologies to process or analyze multimodal learning data (MMLA context), thereby accurately targeting literature closely related to the core topics of this study; the time frame was set to publications after 2016, ensuring the timeliness of the research data and aligning with current trends in the field.

Exclusion criteria are designed to further refine the selection of literature. Non-English documents are excluded due to language limitations and their inconsistency with the linguistic environment of the research setting; non-peer-reviewed literature, such as abstracts, book reviews, editorials, and unpublished works, are excluded due to the lack of a rigorous academic review process, making it difficult to ensure the scientific validity and accuracy of the content; studies that do not apply AI or ML techniques, as well as those that do not use multimodal data or data not derived from learning analytics contexts, are irrelevant to the core content of this research and cannot provide effective support; furthermore, documents that are abbreviated as MMLA but actually refer to other concepts, such as "Multisensor Machine-Learning Approach" and "Multivariate machine learning analysis," are also excluded as they do not align with the concept of multimodal learning analytics defined in this study; duplicate literature can cause data redundancy, affecting the objectivity and validity of the research, and is similarly excluded.

2.3 Study Selection:

The literature selection process follows the basic procedures outlined in the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. It involves four steps: identification, screening, eligibility assessment, and inclusion, ultimately resulting in the inclusion of 87

studies in this systematic literature review (Figure 1).

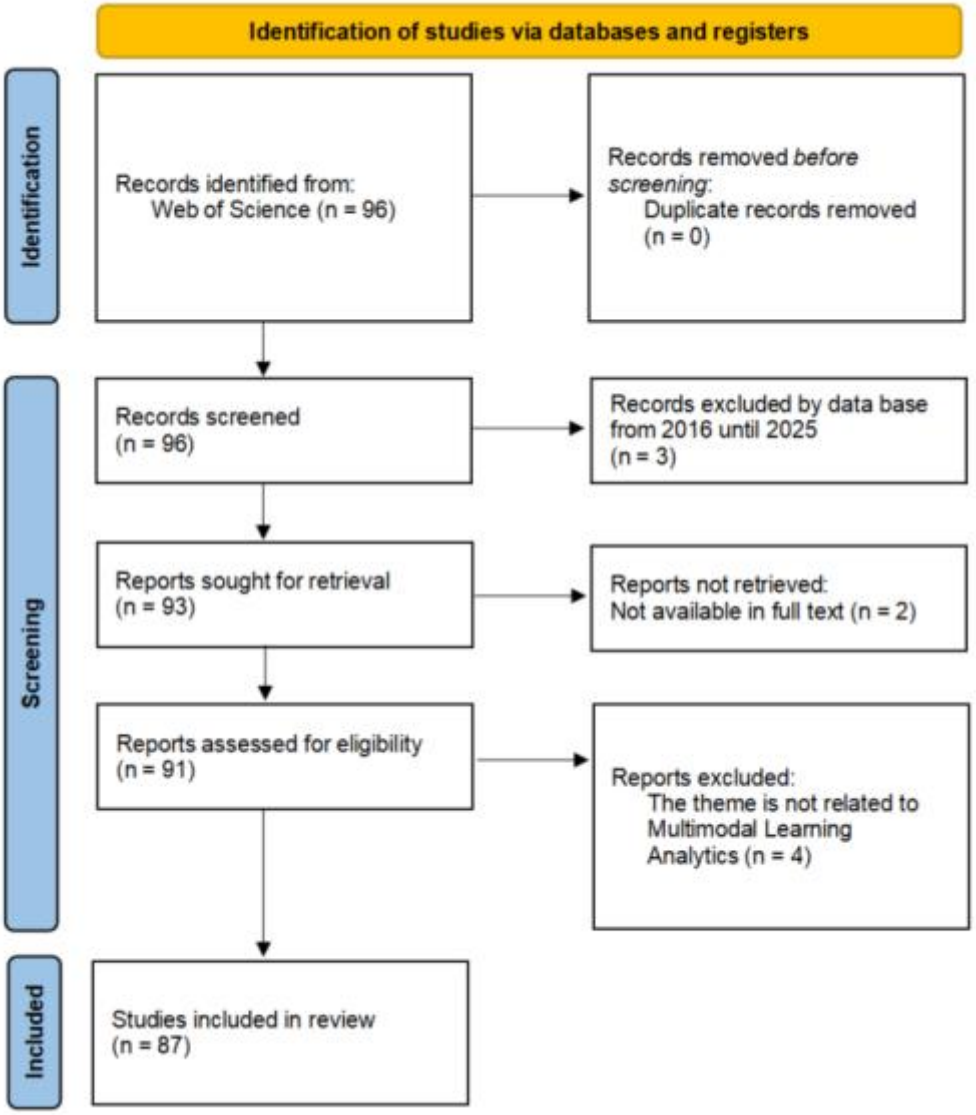

Figure 1: Literature Selection Process

2.4 Data Extraction & Quality Assessment:

Data Extraction: A structured information extraction table was designed to systematically record key information from each included study, including: authors, publication year, source of publication (journal/conference), research objectives/questions, AI/ML methods, types of multimodal data used (such as video, audio, eye-tracking, physiological signals, logs, motion capture, etc.), study subjects (sample size, type), learning contexts/tasks, main findings/conclusions, and reported challenges/limitations.

Quality Assessment: The MMAT (Mixed Methods Appraisal Tool) was referenced as a framework for quality assessment, focusing on the clarity of research design, adequacy of methodology descriptions, completeness of results reporting, and reasonableness of conclusions. Since this review emphasizes outlining the role and trends of AI in MMLA, a strict quantitative scoring of each study was not conducted; however, the assessment results aided in judging the reliability of the research and the weight of the conclusions. The overall impression of the literature quality is that there is a certain degree of heterogeneity in research design and reporting standards.

3 Results

Based on the analysis of the 87 included studies,

we present the results from three aspects: basic characteristics of the literature, thematic/paradigmatic classification, and key findings.

3.1 Study Characteristics:

Publication Trends: From the publication years of the included literature (PY 2016-2025), research on AI in MMLA shows a significant growth trend, especially with a noticeable increase in the number of publications in the last five years, which is consistent with the bibliometric analysis results of Pei et al. [9], indicating that the field is in a rapid development phase.

Types of Literature: Most studies are published in international conferences (such as LAK, AIED, ICALT, EC-TEL, ICMI) and journals in related fields (such as JLA, BJET, JCAL, IEEE TLT, Computers & Education, Sensors, IEEE Access). Conference papers typically present newer exploratory work and system prototypes, while journal articles provide more in-depth analysis and validation.

Research Methods: The majority of studies are empirical, including laboratory experiments, quasi-experiments, and "in-the-wild" studies [11]. Many studies involve system development, model construction, and evaluation. A few pieces of literature are reviews or position papers (e.g., [1, 4, 10]).

Research Background and Modalities: The research covers various stages from K-12 to higher education and vocational training (such as nursing). The learning contexts are diverse, including individual learning, collaborative learning [12], [13], project-based learning [14], online learning [15], special education [16], language learning [17]-[19], and STEM education [20]. The modalities of data used are extremely rich, commonly including:

(1)Visual Data: Including videos (facial expressions, postures, gestures), eye-tracking [21], [22];

(2)Auditory Data: Analyzing the content, prosody, and volume of speech [23], [24];

(3)Physiological Signals: Including electroencephalography (EEG) [25], [26], electrodermal activity (EDA/GSR) [27], [28], heart rate (HR/HRV) [16], [29], and body temperature [28].

(4)Behavioral Data: Interaction logs [30], keyboard and mouse operations, physical sensors (accelerometers, location tracking) [31], [32], handwriting data [22], [33].

3.2 Thematic or Paradigm Classification (Thematic/Synthesis):

Based on the research objectives and the application of AI, the included literature can be categorized into the following main themes (addressing RQ1 and RQ2):

Theme 1: Automation Analysis and Prediction of Learner Status and Behavior Based on AI.

This is the most widespread application of AI in MMLA, mainly including the analysis and prediction of the following aspects:

Cognitive states: predicting cognitive load [22], [28], attention [34], [35], flow state, comprehension level, confusion state [36], etc.

Affective and motivational states: identifying emotions [37], [38], engagement/involvement [39]-[41], stress/arousal levels [29], [42], motivation [26], boredom [36], drowsiness [43], etc.

Behavioral patterns: assessing collaboration quality and its dimensions [44]-[48], identifying help-seeking behavior [49], predicting self-regulated learning (SRL) strategies [50], quantifying specific teaching practices [51], body movements and interaction patterns [52].

Learning outcome prediction: using multimodal features to predict academic performance, task success rates, learning gains, etc. [14], [30], [53], [54].

In terms of AI algorithms, supervised learning algorithms are widely used, such as Support Vector Machines (SVM), Random Forests (RF), Decision Trees (DT), Naive Bayes, and AdaBoost [12]. Deep learning methods are also increasingly common, especially for processing time-series data and complex feature extraction, such as Long Short-Term Memory networks (LSTM) [55], Recurrent Neural Networks (RNN), Convolutional Neural Networks (CNN) (commonly used for image/video analysis), and Transformer-based models. Reinforcement Learning (RL) is also beginning to be explored for personalized education [8].

Theme 2: AI-based personalized feedback and interventions

Using AI to analyze MMLA data, driving adaptive learning systems, intelligent tutoring systems, or providing decision support for teachers to achieve personalized instruction.

Personalized recommendations/adaptations: adjusting learning content, difficulty, or pace based on learner status [8].

Real-time/near-real-time feedback: providing feedback to learners or teachers regarding engagement, collaboration, emotions, etc. [25], [35], [52], [56].

Agent Interaction: Developing Embodied Conversational Agents (ECAs) or social robots that

utilize MMLA to understand and respond to learners, facilitating interaction and learning [57], [58].

In the application of AI technologies in this area, in addition to predictive models, natural language processing (NLP) techniques are involved to analyze text/audio interactions and generate feedback [7], [59], and reinforcement learning is used to optimize intervention strategies [8].

Theme 3: AI-Driven Multimodal Data Fusion and Feature Engineering

AI technologies are used to process and integrate heterogeneous data from different sensors and extract meaningful high-level features.

Data Fusion Strategies: Exploring early fusion (feature-level fusion), late fusion (decision-level fusion), or hybrid fusion methods [36], [60].

Feature Extraction/Selection: Automatically extracting features using deep learning or selecting key multimodal features related to learning using ML techniques (such as Principal Component Analysis (PCA), feature importance ranking) [14].

Theme 4: AI-Supported MMLA System and Framework Development

The research focuses on designing and implementing MMLA platforms, architectures, or toolkits that integrate AI functionalities.

Reference Architecture: Proposing a logical architecture for MMLA systems, clarifying modules for data collection, processing, analysis, and presentation [61], [62].

Toolkits/Platforms: Developing user-friendly MMLA tools to lower the barriers for research and application [37], [52].

Design Framework: Proposing methodologies or models for MMLA system design [18], [19].

3.3 Key Findings:

In the field of Multimodal Learning Analytics (MMLA), AI/ML models demonstrate powerful data analysis capabilities, with their core advantages first reflected in the effective identification and prediction of learning-related states and behaviors. The accuracy of such models is often significantly better than random guessing, and they even show extremely high precision in specific tasks; for example, the prediction accuracy of behavior change reached 98% in literature [16]. Furthermore, integrating multimodal data often yields more accurate and robust predictive results than single-modal data [60,50,43,63], thanks to the complementarity of different modal data: physiological signals can reflect the internal states of learners, while behavioral data presents external performances, and the combination of both can construct a more complete learning profile. Specifically, certain modalities are often highly correlated with specific psychological or behavioral constructs: speech features are closely linked to collaborative communication skills [24], eye-tracking data can reveal attention distribution and cognitive load states [22], and physiological signals (such as Electrodermal Activity (EDA) and Heart Rate (HR)) can effectively represent emotional arousal, stress levels, and cognitive load [27]-[29]. In terms of technical pathways, although deep learning models show unique potential in handling high-dimensional time-series data such as video and EEG [55], traditional ML methods are still favored by researchers in scenarios requiring transparent analysis due to their stronger interpretability [5], [14]. It is noteworthy that the current application of AI in MMLA is shifting from laboratory environments to real classroom settings; however, this process faces many challenges—the generalizability of models is significantly influenced by contextual factors such as task types, disciplinary differences, cultural backgrounds, and population characteristics [5], [13], [16], [45]. Meanwhile, as the application of technology deepens, ethical concerns continue to rise, particularly regarding data privacy protection, algorithm fairness, transparency, and accountability mechanisms (FATE: Fairness, Accountability, Transparency, Ethics), which have become important dimensions that cannot be ignored in research and practice in this field [61], [64], [65].

4. Discussion

4.1 Significance of Main Findings: (Answering RQ1 and RQ2)

The results of this review clearly indicate that AI is not merely a tool for MMLA, but is profoundly shaping its development direction and capability boundaries. AI technology enables researchers to:

(1)Go beyond surface phenomena: By analyzing multidimensional data such as physiological and behavioral data, AI can reveal internal learning states (such as cognitive load and emotional fluctuations) that traditional methods struggle to capture, as well as their complex relationships with overt behaviors and learning outcomes.

(2)Achieve large-scale, automated analysis: The ability of AI to process massive MMLA data makes it possible to conduct fine-grained analyses of large learning populations and automate processes that previously required extensive manual coding (such as behavior annotation and collaboration quality

assessment).

(3)Empower personalization and adaptability: Based on AI predictions and analyses, more intelligent and adaptive learning environments and interventions can be constructed, truly achieving tailored education, such as providing timely scaffolding through agents [57] or adjusting learning paths [8].

(4)Facilitate the integration of theory and practice: AI models can be used to test learning theories (such as cognitive load theory and self-regulated learning theory) in real multimodal data and provide data-driven insights and tools for educational practices (e.g., [56] using AI to reveal effective teaching practices).

The role of AI is shifting from retrospective analysis to real-time monitoring and proactive intervention, marking a development towards a more practically impactful direction in the field of MMLA.

4.2 Comparison with Previous Reviews:

The findings of this study present both consistencies and supplements compared to previous MMLA reviews. Firstly, consistent with the bibliometric analysis conducted by Pei et al. [9], this study also confirms the rapid development trend in this field and the central role of AI/ML within it, further validating previous research's judgments on industry trends. In contrast to the review by Giannakos and Cukurova [10], which focuses on theoretical applications, this review emphasizes the role and methods of AI technology itself; however, the exploration process also indirectly reflects that many current studies still tend to lean towards the technical implementation aspect, lacking in-depth theoretical integration, a finding that supports their viewpoint that theoretical applications need further strengthening [66]. Meanwhile, this review aligns closely with the review by Prinsloo et al. [1], which emphasizes ethical and privacy issues, also finding that ethical considerations, especially topics related to FATE (Fairness, Accountability, Transparency, Ethics), have become hot and challenging issues in current research [64]. Compared to the review by Shankar et al. [61] on early MMLA frameworks, this study reveals continuous progress in system architecture, data models, and tool development [37], [62], with an increasingly in-depth integration of AI components. It is worth emphasizing that the uniqueness of this review lies in its systematic focus on the specific roles, methodological classifications of AI in MMLA, and the key findings and challenges it brings, thus providing a comprehensive and detailed picture of the development in this interdisciplinary field over the past decade.

4.3 Gaps & Future Research: (Answering RQ3)

Despite significant progress, the application of AI in MMLA still faces numerous challenges, pointing to future research directions:

(1)Enhancing model generalizability: This is one of the most prominent challenges. Most models perform well in specific contexts, but their performance drops sharply when applied across tasks, populations, cultures, and environments [5], [13]. Future research needs to adopt more robust feature engineering, domain adaptation techniques, and multi-task learning, and validate in a more diverse range of real-world scenarios.

(2)Enhancing AI explainability (Explainability, XAI): "Black box" models are difficult for educators and learners to understand their decision-making basis, limiting trust and application [41]. There is a need to develop and apply explainable AI technologies that provide pedagogically understandable insights and feedback.

(3)Deepening ethical considerations (Ethics & FATE): How to enhance learning using MMLA data while protecting student privacy, ensuring algorithmic fairness, avoiding biases (such as gender and racial biases [34]), and clarifying data ownership and usage rights are urgent issues that need to be addressed [64], [65]. Clear ethical guidelines and technical solutions need to be established.

(4)Addressing data quality and noise: Data collected from real-world scenarios ("in-the-wild") often contains noise, missing values, and synchronization issues [11], [12]. More effective signal processing, data cleaning, and noise-resistant AI algorithms are needed.

(5)Strengthening theoretical guidance and integration: The construction of AI models and the interpretation of results should be more closely aligned with learning science theories, avoiding a technology-driven approach that neglects the essence of education [10], [66].

(6)Promoting the translation of research into practice: Bridging the gap between laboratory research and large-scale classroom applications, developing tools and systems that are friendly to teachers and students and easy to integrate into existing teaching processes [11], [37].

(7)Exploring more advanced AI technologies: for example, exploring the application of Generative AI (GenAI) in MMLA data augmentation, personalized feedback generation, and data storytelling presentation [49], [67].

4.4 Implications for Practice/Policy:

Practical Level: AI-driven MMLA can provide teachers with richer perspectives on student understanding and classroom management tools (such as automated collaborative monitoring dashboards [35, 52]). Personalized learning systems can be developed to offer targeted learning support and feedback [8]. It can be used for student reflection tools to help them understand their learning processes [64].

Policy Level: Educational institutions and policymakers need to establish ethical guidelines and privacy protection policies regarding the collection and use of MMLA data and the application of AI algorithms. Support should be provided for the development of standardized data formats and interfaces to promote system interoperability. Consideration should be given to providing relevant training for teachers to equip them with the ability to understand and effectively utilize AI-driven MMLA tools [56].

5. Limitations

This systematic literature review has limitations in several aspects. First, the database usage was relatively singular, only retrieving literature from the Web of Science database, which may have led to the omission of relevant literature indexed in other databases such as Scopus, PubMed, and ACM Digital Library. Second, the search terms used may not have covered all relevant studies, especially those that did not use standard terminology but are substantively related to the field. Additionally, there is a clear bias in language, as the review only included English literature, neglecting significant research findings in other languages, which limits the comprehensive analysis of related research globally. Furthermore, in the quality assessment phase, no strict quantitative quality scoring was conducted; the judgment of literature quality was based solely on the researchers' overall assessment, lacking more precise and quantitative standards. Moreover, there is subjectivity in the thematic summarization process, as the categorization of themes and extraction of key findings inevitably carry the researchers' subjective interpretations, which may affect the objectivity of the conclusions. Finally, this study did not include gray literature, such as theses and technical reports, which were not analyzed, resulting in a lack of completeness in the types of literature considered.

6. Conclusion

This systematic literature review systematically reviewed the research on Artificial Intelligence (AI) in the field of Multimodal Learning Analytics (MMLA) over the past decade. The results indicate that AI has become the core technological engine of MMLA, primarily functioning in automating the analysis and prediction of complex states and behaviors in learning processes, achieving personalized feedback and interventions, facilitating the integration and interpretation of multimodal data, and supporting the design and development of related systems. Supervised learning and deep learning are the main AI methodologies employed, which have made significant progress in understanding collaborative learning, emotional states, cognitive load, and more.

However, the application of AI in MMLA also faces severe challenges, particularly regarding the generalizability of models, the interpretability issues arising from the "black box" nature of AI algorithms, and the increasingly prominent ethical and privacy (FATE) risks. Future research needs to focus on enhancing the robustness of technology while paying more attention to the construction of ethical norms, the exploration of explainable AI, the deep integration of theory and technology, and the effective translation of research findings into real educational practices.

Looking ahead, with the continuous advancement of AI technology (such as the integration of generative AI) and deeper research, AI-enabled MMLA is expected to provide strong support for creating more effective, equitable, and personalized learning experiences, provided that its development and application are advanced in a responsible, ethical, and human-centered manner.

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Research on the Practice Path of AI Empowered Integration of Physical Education and Academic Education

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Abstract： The integration of AI in the fields of education and sports has gained increasing attention with the rapid development of artificial intelligence technology. This paper first explores the role of AI in the integration of physical education and academics, focusing on its application in the prevention of sports injuries and intervention in academic burnout. Subsequently, the article constructs practical paths for the integration of physical education and academics, including integrated models of education and sports, and the application of artificial intelligence technology in education. Additionally, it discusses challenges faced in the process of AI-enabled integration, such as ethical and safety issues in technology application, optimization and popularization of artificial intelligence technology, and proposes corresponding countermeasures. Through in-depth analysis, this study aims to provide theoretical guidance and technical support for promoting innovative development in the fields of education and sports through the practice of integration.

Keywords: Artificial Intelligence; Integration of Physical Education and Academics; Prevention of Sports Injuries; Intervention of Academic Burnout

1.Introduction

The advancement of technology has a profound and comprehensive impact on various fields in today's society, with the integration of education and sports being at the forefront. It creates new opportunities and challenges for the integration of physical education and academics, with artificial intelligence being a technology full of transformative potential. This study, taking the prevention of youth sports injuries and intervention of academic burnout as examples, conducts an in-depth exploration of the practical paths for integrating physical education and academics through the use of artificial intelligence, which holds significant practical significance.

As a key means of cultivating well-rounded talent, the integration of physical education and academics aims to organically combine the two, breaking down the barriers between education and sports. However, many issues have arisen in the traditional practices of physical education and academic integration in the past. For instance, students in some regions find it difficult to fully access quality physical education due to the uneven distribution of educational resources; the methods of physical education teaching are relatively monotonous and struggle to meet the diverse needs of students; and there is a lack of effective means and strategies aimed at preventing youth sports injuries and intervening in academic burnout.

With the rise of AI technology, a brand new vision has emerged, providing a new solution to the aforementioned problems. Big data analysis can offer precise insights into students' physical conditions, exercise habits, and more, thereby reducing the risk of sports injuries and providing strong support for personalized training plans. At the same time, leveraging intelligent education systems allows for real-time monitoring of students' learning states, capturing early signs of academic burnout, and implementing targeted interventions, which can significantly assist students' learning conditions.

Furthermore, artificial intelligence can optimize the allocation of educational resources and sports, promoting improvements in teaching effectiveness and quality. For example, creating a more vibrant and engaging learning and training environment for students, utilizing virtual reality and augmented reality

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technologies, can greatly stimulate students' enthusiasm and initiative.

Based on the above analysis, the integration of physical education and AI shows broad development prospects and immense potential. However, in promoting this integration, it is essential to thoroughly consider the feasibility, effectiveness, and potential negative effects of technology applications to ensure that it can genuinely promote the comprehensive health development of young people. This study will deeply analyze the specific applications and practical paths of artificial intelligence in the integration of physical education, contributing valuable references and insights for advancing this integration.

2. The Role of Artificial Intelligence in the Integration of Physical Education

2.1 Application in Sports Injury Prevention

In the context of the integration of physical education, the application of artificial intelligence in sports injury prevention is of significant importance. Sports injuries not only affect the physical health of young people but may also hinder their academic performance and future sports development. The introduction of artificial intelligence technology brings new opportunities for sports injury prevention.

One aspect involves the use of intelligent sensors and monitoring devices to collect real-time data on various parameters such as movement posture, speed, and strength during youth sports activities. By analyzing this data with artificial intelligence algorithms, accurate assessments of injury risks can be made, allowing for the early detection of potential injury hazards. For example, intelligent devices can monitor key indicators such as jumping and landing postures in basketball; if the movement patterns are deemed unreasonable, timely warnings can be issued to alert athletes and coaches to adjust their movements.

On another basis, artificial intelligence sports simulation technology, which is grounded in artificial simulation and simulated physical training, can create personalized training plans for young athletes. It simulates the most suitable modes and intensities of exercise, thereby reducing the likelihood of injuries, based on individual physical conditions, exercise habits, and injury history. For instance, for adolescents with a history of ankle sprains, high-intensity directional changes will be appropriately reduced, while strength training around the ankle will be emphasized in the training plan.

Moreover, AI-assisted recovery treatment in sports injury prevention is also a crucial aspect, addressing the issue of supportive treatment for injuries. After an injury occurs, it is essential to utilize intelligent rehabilitation equipment and software to implement precise monitoring and assessment of the recovery process to ensure the scientific and effective nature of rehabilitation training. Additionally, by analyzing different types of injuries through big data, rehabilitation patterns can be summarized as references for future prevention.

Furthermore, the application of intelligent management of sports venues and equipment in sports injury prevention is still lacking. By employing sensing and monitoring systems to oversee the flatness of the field, the conditions of equipment usage, and other factors in real-time, potential risk factors causing injuries can be identified and addressed promptly, thereby enhancing the safety of the environment and achieving the goal of preventing sports injuries.

In conclusion, the application of artificial intelligence in preventing youth sports injuries spans many aspects and levels. It can provide comprehensive protection for the integration of sports and physical education, as well as for the healthy growth of youth, through risk assessment before sports, real-time monitoring during activities, and rehabilitation treatment after injuries. However, in practical applications, attention must be paid to the accuracy and safety of data, and the combination of technology with human-centered care is essential to serve the health of sports. This organic combination of technology and humanistic care will ensure that artificial intelligence truly serves the sports health of youth.

2.2 Strategies for Intervening in Academic Burnout

AI is applied in the field of sports injury prevention, under the overarching context of the integration of physical education and academics, highlighting its critical value. The occurrence of sports injuries not only adversely affects the physical and mental health of adolescents but also poses certain constraints on their academic progress and athletic development in the future. Moreover, the integration of artificial intelligence technology presents a new opportunity for preventing sports injuries, which is an inevitable requirement for addressing sports-related harm.

AI can collect various data on adolescents in real-time during sports activities through intelligent sensors

and monitoring devices, just like it does for sports posture, speed, and strength. By analyzing this data with artificial intelligence algorithms, precise assessments of sports risks can be achieved, allowing for early insights into potential injury hazards. For instance, in basketball, intelligent devices can monitor key indicators such as jump height and landing position. If the movement patterns do not conform to reasonable standards, the system will immediately issue a warning and prompt adjustments for athletes and coaches, serving as a reminder.

AI can help construct sports simulation and modeling technologies for adolescents, aiming to achieve personalized training plans. It simulates the most suitable modes and intensities of exercise based on individual physical conditions, exercise habits, and past injuries, thereby reducing the likelihood of injury. For example, in a training plan, moderately reducing high-intensity directional changes and focusing on strengthening the muscles around the ankle for adolescents who have previously experienced ankle sprains.

A key component of sports injury prevention is the auxiliary human treatment in rehabilitation therapy. After an injury occurs, intelligent rehabilitation devices and software can provide precise monitoring and evaluation of the rehabilitation process, ensuring the scientific and effective nature of rehabilitation training. Additionally, analyzing a large amount of data can summarize the healing patterns of different types of injuries, providing valuable references for future prevention efforts.

The intelligent management of sports venues and equipment in injury prevention also relies on artificial intelligence methods. Through sensors and monitoring systems, real-time monitoring of the evenness of the ground and the condition of the equipment can be achieved, allowing for timely alerts regarding potential hazards and facilitating maintenance and improvement efforts, ensuring targeted and effective actions.

In summary, the application of artificial intelligence in preventing youth sports injuries is diverse and multi-layered, representing an interdisciplinary approach that intersects various fields. The application of AI in preventing sports injuries among adolescents is multifaceted and operates on multiple levels, providing comprehensive protection for youth and promoting the deep development of the integration of physical education and the healthy growth of adolescents, from risk assessment before sports, real-time monitoring during activities, to rehabilitation treatment after injuries. However, in practical applications, the security of data also requires attention, and the organic integration of technology with humanistic care is essential, which serves the intelligent technology for the health of youth sports.

3.Construction of Practical Paths for the Integration of Physical Education and Academics

3.1 Integration Model of Education and Sports

In the growth process of adolescents, the integration of education and sports occupies a crucial position, and the integration model of education and sports is the core point for achieving the empowerment of physical education integration through artificial intelligence.

Integration of education and sports is not merely an accumulation, but rather a shaping of an organic fusion form. This form must comprehensively consider the characteristics and needs of the physical and mental development of adolescents. Additionally, in terms of curriculum design, it should break through the traditional isolation of physical education courses, which are relatively disconnected from other subjects. The knowledge, skills, and culture of sports should be integrated with content from disciplines such as science, constructing a comprehensive curriculum framework. For instance, in physics courses, knowledge of mechanics can be introduced to help students intuitively understand physical principles through sports; in language courses, writing training related to sports spirit and athlete achievements can be arranged to cultivate students' cultural literacy and values.

Innovative integration in teaching methods is also very necessary. Utilizing project-based learning and group collaboration, students can develop teamwork and problem-solving skills through sports activities. For example, organizing students to plan sports events, from arranging activities and formulating rules to promotion, requires students to take on different responsibilities and participate actively. This not only exercises the skills of sports organization but also enhances comprehensive qualities such as communication and coordination.

The integration of the teaching staff is also a key focus. Encouraging physical education teachers to engage in interdisciplinary communication and collaboration with teachers from other subjects to jointly carry out research activities. In teaching research, physical education teachers and teachers from other subjects can promote each other and jointly

develop teaching outcomes. This allows physical education teachers to share their experiences and methods in sports training, while teachers from other subjects can collaborate, supported by their subject knowledge, to plan more targeted and comprehensive teaching programs for students.

The integration of education and sports is also an important channel for creating campus culture. By hosting various sports cultural activities such as sports-themed speech competitions and art exhibitions, students can experience the charm of sports and appreciate its value in a rich sports cultural atmosphere.

At the same time, it is essential to strengthen the cooperation among schools, families, and communities. Parents should actively participate in sports activities organized by schools, setting a good example for children in loving exercise and labor; communities should create more opportunities for students to engage in sports activities, providing more sports venues and facilities.

In summary, to construct an integrated model of education and sports, it is necessary to shape a comprehensive and multi-layered integration system, starting from various aspects such as curriculum design, teaching methods, teacher resources, campus culture, and cooperation both inside and outside the school, to create a favorable environment for the comprehensive development of adolescents.

3.2 Application of Artificial Intelligence Technology in Education

In the context of the macro background of the integration of physical education and academic education, the application of artificial intelligence technology in the field of education shows significant importance and broad development prospects.

Artificial intelligence technology can "customize" exclusive learning plans and course content for each student, based on in-depth analysis of data regarding students' learning behaviors, interests, and knowledge mastery, thus achieving a personalized learning experience. For example, in physical education courses, artificial intelligence can accurately push relevant preventive knowledge and training programs to meet individual needs, targeting students with specific athletic talents or those at risk of certain sports injuries. For instance, AI can provide targeted strength training and sprint technique guidance for students with sprinting potential; it can also push scientific protective measures and rehabilitation training plans for students at risk of knee injuries.

Smart auxiliary tools have shown outstanding performance in promoting teaching outcomes. Intelligent teaching software that can simulate various sports environments allows students to familiarize themselves with and master relevant skills in advance, practicing and training in a virtual environment, thereby minimizing the risk of injuries in real sports. Additionally, these tools can monitor students' learning status and progress in real-time, providing timely and accurate feedback to teachers, facilitating timely and precise adjustments in teaching strategies to achieve targeted objectives. For example, in basketball education, SmartSoftware has a function that simulates game scenarios, enhancing students' tactical understanding and teamwork skills during virtual competitions.

AI technology also plays a significant role in the allocation of educational resources. It can reasonably plan physical education classes and teaching activities, improving the utilization efficiency of resources based on the specific teaching staff and venue conditions of the school. For instance, in the absence of sufficient teaching staff, the intelligent teaching system assists in providing remote guidance and online courses for students.

Artificial intelligence in the field of educational assessment plays a crucial role. It can conduct comprehensive and objective evaluations in many aspects, such as students' sports skills, academic achievements, and physical and mental health, thereby providing a scientific basis for educational decision-making.

However, there are some difficulties encountered in the application of AI in education. Issues such as data security and personal privacy protection must be taken seriously to prevent the leakage of students' personal information, and it is not sufficient to address data security and privacy protection issues only to a certain extent. Meanwhile, teachers and students may face certain difficulties in accepting and applying new technologies, which indicates a need for training and guidance.

In summary, the potential of artificial intelligence technology applied to the integration of education and physical education is significant, but fully leveraging its advantages to provide strong support for the overall development of youth requires continuous exploration and improvement in practical operations.

4.Empowerment of artificial intelligence

4.1 Ethical and Security Issues in Technology Application

In the process of integrating education and physical education with the assistance of artificial intelligence, the ethical and security issues involved in technology application cannot be ignored. With the widespread use of artificial intelligence technology in education and sports, a series of ethical and security challenges are gradually emerging.

From the perspective of data collection and usage, there are ethical concerns. A vast amount of personal data, including physical condition, sports performance, and learning habits, is collected to achieve precise prevention of sports injuries and intervention for academic burnout. However, ensuring that the collection and use of this data are legally authorized and guaranteeing data security and privacy have become very important issues that need to be addressed. If data is leaked, there is a significant possibility of serious harm to the personal rights of youth. For example, if criminals obtain personal health data, it could be used for illegal purposes, causing great distress to young people.

Regarding ethical issues, algorithmic bias is also very important. The decisions and predictions made by artificial neural systems are generally based on algorithms, but due to subjective factors from developers and data biases, algorithms may lead to unfair results. When assessing the risk of sports injuries or the degree of academic burnout, biases in algorithms may lead to incorrect judgments about certain individuals, thereby affecting their access to appropriate interventions and support.

Moreover, the application of artificial intelligence technology in the integration of education and physical education may lead to excessive dependence. If educators and sports coaches overly rely on technology for decision-making interventions, it may undermine their subjective judgment and professional experience, thus weakening the essence of education and sports.

Furthermore, security issues must not be overlooked. Reliable and stable artificial intelligence devices and systems are extremely important. Once a malfunction or error occurs, it may directly harm the physical and mental health of youth, leading to significant risks. For instance, false alarms from sports monitors may result from training errors, increasing the likelihood of injuries.

In order to effectively address the ethical and safety issues mentioned above, and to reduce the occurrence of causes and improper phenomena, it is necessary to establish a complete set of laws and regulations, clarify the norms regarding data collection, usage, and sharing, and strengthen the review and supervision of these aspects. At the same time, both educators and PEAS coaches should maintain a critical perspective on technology, treating artificial intelligence as an auxiliary tool rather than relying entirely on it. Additionally, there should be an emphasis on quality testing and safety assessment of artificial intelligence technology in the integration of physical education and academics to ensure reliable technical standards, keeping everything well-informed and understood.

In conclusion, only by fully recognizing and properly addressing the ethical and safety issues related to the application of technology can the positive role of artificial intelligence in the integration of physical education and academics be better realized, thus providing strong support for youth and enabling their healthy and comprehensive development.

4.2 Optimization and Promotion of Artificial Intelligence Technology

In the current social context, with the expanding application of artificial intelligence technology in the integration of physical education and academics, the speed of its advancement is unprecedented, and its application scope continues to broaden. However, for the optimal configuration of technology and the promotion of its application, it is particularly important to ensure that artificial intelligence plays a prominent role in the integration of physical education and academics.

Regarding the optimization of artificial intelligence technology, this is the core point for enhancing its application effectiveness in the integration of physical education and academics. Although current artificial intelligence technology has provided some assistance in preventing youth sports injuries and addressing academic burnout within a certain scope, there are still many deficiencies. For instance, the accuracy and stability of algorithms need improvement, and data collection and analysis are not comprehensive enough. For example, in some artificial intelligence applications aimed at preventing youth sports injuries, the predictions of potential injury risks are not accurate due to algorithm shortcomings. To enhance the effectiveness of artificial intelligence technology, it is necessary to increase investment in research and development, attract a large number of excellent scientists to this field, and strengthen collaboration across different disciplines, combining knowledge and skills from computer science,

education, sports science, and other fields to jointly address technical challenges.

Another important means to promote the development of the integration of physical education and academics is to popularize artificial intelligence technology. Although artificial intelligence technology holds great potential, its penetration in practical applications remains relatively low. Many schools and educational institutions find it difficult to fully leverage the advantages of artificial intelligence technology due to a lack of relevant equipment and technical support. Accordingly, governments and society should increase investment in the education sector, equipping schools and educational institutions with necessary hardware facilities and providing technical training, enabling more people to proficiently use and master artificial intelligence technology. This is a requirement for governments and society to enhance the provision of necessary hardware facilities to schools and educational institutions. For instance, some local governments have provided dedicated artificial intelligence laboratories and training courses for schools, significantly improving the level of artificial intelligence technology application in local schools.

Furthermore, the functions and advantages of artificial intelligence technology in the integration of physical education and academics need to be vigorously promoted, so that more people are aware of them. Schools and educational organizations should be fully motivated to engage in demonstrations of successful cases and applications through relevant seminars, training courses, and demonstration projects.

At the same time, it is essential to establish comprehensive standards and norms for the safe and reliable application of artificial intelligence technology in the integration of physical education and academics. This is to eliminate the risk of personal information leakage and further strengthen data privacy.

In summary, one important way to achieve greater value in the integration of physical education and academics is to optimize and promote artificial intelligence technology. While significantly increasing the efforts to popularize and promote it, continuous optimization of technology, improvement of performance and accuracy are necessary to effectively promote the deep integration of physical education and academics, thereby supporting the healthy growth and comprehensive development of youth.

5.Conclusion

This research topic deeply explores the practical path of empowering the integration of physical education and academic education with artificial intelligence in China, using the prevention of youth sports injuries and the intervention of academic burnout as examples, fully demonstrating its significant meaning and great value.

In the analysis of the role of artificial intelligence in the integration of physical education and academics, its application can be found in the field of injury prevention. By utilizing cutting-edge monitoring technology and data analysis methods, potential risks can be identified, thereby providing a solid and reliable guarantee for the physical activities of adolescents, ensuring their safety. Taking the strategy of intervening in academic burnout as an example, the use of intelligent tutoring and personalized learning plans can effectively alleviate the burnout caused by academic pressure, stimulating students' interest and initiative in learning.

The integrated model of education and sports creates more favorable conditions for the organic fusion of knowledge learning and physical exercise in the process of constructing practical paths for the integration of physical education and academics, facilitating the all-round development of adolescents. The application of artificial intelligence technology in the education sector brings new innovations and transformations to teaching methods and learning experiences.

However, it also faces a series of challenges in the process of empowering through artificial intelligence. Issues related to data privacy protection, algorithm bias, and other ethical and security concerns involved in technology applications should not be underestimated. At the same time, to ensure widespread application and maximize benefits, continuous investment and effort are needed for the optimization and popularization of artificial intelligence technology.

Future development should further strengthen interdisciplinary research, integrating expertise from education, sports, computer science, and other related fields to continuously improve the artificial intelligence empowerment model for the integration of physical education and academics. Moreover, the government and various sectors of society should increase support for relevant research and practical applications, providing necessary resources and policy support. To better utilize artificial intelligence technology to serve the growth of adolescents, educators and sports coaches also need to continuously

improve their professional skills to achieve the goal of supporting youth development.

In summary, the integration of artificial intelligence in physical education and academics belongs to a realm of infinite potential and numerous opportunities. It is essential to adopt a proactive attitude to face challenges, continuously explore innovations, and pave a broader path for the healthy growth and comprehensive development of adolescents.

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How do educational leaders build trust in new schools

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Abstract： Although we know that the role of trust in an organization is very important, and trust has been paid attention to in various fields. As an important organizational group, schools lack a large number of studies on trust issues, and few studies have focused on the mutual trust between school leaders and teachers, which is related to teacher performance. In my experience as a volunteer teacher after undergraduate, I found that the quantity and quality of teachers are important in building a good new school. And two reasons can reduce the teacher turnover rate, one is the quality of teachers, the other is the school environment. As for the school environment, principals must foster "culture of trust" in schools. Through quantitative research in a large amount of literature, I learned how important "culture of trust" is in a school. Then I used three theoretical frameworks: transformational leadership, distributed leadership and trust leadership, combined with chart data analysis and case study, to analyze how school leaders build "culture of trust" in schools. In addition, the assignment gives the research on the mutual trust between school leaders and teachers, which is related to teacher performance, and gives some specific applications and solutions, as well as some limitations.

Keyword: Culture of trust; Educational leadership; Principal-teacher mutual trust; Teacher performance; Transformational leadership

1. Introduction

Trust has already attracted the attention of various fields, and a large number of relevant literature can be found in all fields. Through consulting a lot of literature, I found that many scholars after a long period of research believe that trust on the development of various industries cannot be ignored. However, as an important organizational group, schools lack a large number of studies on trust issues, and few studies have focused on the mutual trust between school leaders and teachers, which is related to teacher performance. After graduating from my university, I volunteered to teach in a rural school of remote village in China, which had just been established in the last few years. During the volunteering period, I found that the teacher turnover rate was extremely high, making the children's education inconsistent, which made me feel anxious. Based on my own personal experience, I find two reasons to reduce the teacher turnover rate, one is the quality of teachers, the other is the school environment. Therefore, this assignment starts through these two points to develop concretely. As for the first point, this assignment proves through literature and chart that developing a good school, the values of teachers: morality, professionalism, identity, motivation, commitment, and resilience are important. As for the second point, this assignment believes that to create a good school environment, "culture of trust" is very important, and the construction of "culture of trust" needs to be analyzed from multiple perspectives, including principal's trust in teachers, teachers' trust in principals, trust in colleagues, trust in students, parents and schools. Based on the quantitative research of a large number of literature, this assignment analyzes the importance and concrete measures of trust in each aspect and angle in detail by combining two real-life cases and graphs, and holds that the principal must take the lead. The principal must take the first step to construct the "culture of trust", and then analyze the principal should apply three theoretical frameworks: transformational leadership, distributed leadership and trust leadership, to build "culture of trust" in schools. This assignment also gives the research on the mutual trust between school leaders and teachers, which is related to teacher performance. Therefore, in order to build a good "culture of trust" in schools, mutual trust between leaders and teachers is very important, and the

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trust of leaders to teachers is a very important step. Only when leaders and teachers deal with the "culture of trust" between them, parents and students will trust the principal, teachers and the whole school, and through mutual trust, the "culture of trust" of the whole school will be constructed. In the second half of this assignment, it gives detailed and specific analysis that how principals can use three theoretical frameworks: transformational leadership, distributed leadership and trust leadership, to build the trust between leaders and teachers, and give some specific applications and solutions. Although trust can solve many problems in education management, there are still many problems, so at the end of this assignment, some limitations are given.

2. Literature Review

2.1 Background

In recent years, the study of trust has aroused the attention and interest of different disciplines. Numerous related literature can be found in philosophy, psychology, sociology, economics, political science and other fields. The word organizational trust has also gradually attracted attention and been further discussed. As an important organizational group, schools lack a large number of studies on trust issues. With the establishment of new school management systems, new working relationships are often required, and the need for high initial trust is growing. Therefore, many factors affecting trust need to be analyzed. Trust is an important social resource and a very important existence to develop a good school. Studies have shown that teachers trust their schools and colleagues more than their leaders, with two-thirds saying their leaders are not trustworthy (Hollis, 1998). Some leaders pay too much attention to how to improve the performance of the school and ignore the concern for teachers, which inevitably leads to a certain trust problem in the teacher team. In the literature, it is widely believed that trust enables actors to conquer collective action problems and achieve common goals in more effective ways (Ostrom, 1990; Putnam, 1993; Tavits, 2006). Rational actors can develop the insight that a relationship of trust is necessary if they want to realize their goals in society in a partnership with others (Gambetta, 1988). Even though they know that they are occasionally disappointed by the behaviour of some of their compatriots, they are convinced, with rational insight, that trust is the only possible means of ensuring collective action (Hollis, 1998).

However, few studies have focused on the mutual trust between school leaders and teachers, which is related to teacher performance (Kim et al., 2016). Stable and lasting cooperation between people is mainly based on mutual trust. Perceived mutual trust has a positive effect on task performance and performance, controlling interpersonal promotion after leadership trust and perceived trust. In addition, interpersonal facilitation and task performance increase with trust in leaders (Hooghe et al., 2012). The concept of trust is getting more and more attention in the research of organization (Balliet et al., 2013; Colquitt et al., 2007; Ferrin et al., 2008; Salamon et al., 2008). Trust is an important factor in the relationship between superiors and subordinates (Brower et al., 2009; Dirks & Ferrin, 2002). When subordinates trust them, they are more likely to accept the manager's influence (Dirks & Ferrin, 2002). The development of mutual trust is a stable and lasting collaborative relationship and people's need for more effective cooperation (Brown & Greany, 2017). Trust has become a central concept in organizational research (Campagna et al., 2009). Trust is associated with a number of important outcomes, including leadership effectiveness and teamwork (Colquitt et al., 2007; Dirks & Ferrin, 2002). Many existing studies have shown that trust can motivate members to perform better and better (Baer et al., 2015; Salamon & Robinson, 2008). Baer et al. (2015) believe that teachers' perceived trust develops with leaders' actual trust behaviors. Trust is often related, it is"two sides of the same coin." (Campagna et al., 2009). In return, teachers are more likely to be hard-working to meet the performance standards and expectations demanded by their leaders. In a relationship of mutual trust, both parties are also willing to communicate more openly and effectively, so that teachers can better understand their leaders' expectations of their tasks and get high task performance (Mohr & Nevin, 1990). The relationship of trust between teachers and leaders has a greater impact on schools. Spreitzer et al.(2002) and Colquitt et al.(2007) showed that trust in leaders leads to higher job performance.

2.2 Reflection on experiences

I volunteered to teach in a rural school of remote village in China after undergraduate, which had just been established in the last few years. When I worked as a volunteer teacher, I found that there is a particularly high teacher turnover rate in rural areas. The education for children was discontinuous because teachers left after several months of teaching, which mainly includes two reasons, one is the quality of

teachers themselves, the other is the school environment Essentially, two sources of support are needed if teachers are to continue their effort to provide a differentiated and knowledgeable education for all students. The first source of support is their intrinsic values: ethics, professionalism, identity, motivation, commitment and resilience. The second source of support is the quality of the school environment. For those who strive to remain resilient at all stages of their careers and in various school settings, their school work environment are considered the most important factor (Day & Gu, 2010). The principal is responsible for the school environment (Day, 2017).

On the first source of support, Day et al.(2005) said if you believe a job is worth doing, you are committed. Research from the UK and Australia has shown that the teaching input is not limited to this but deeper. It involves a range of values that are the driving force of commitment throughout the career, regardless of the environment (Day et al., 2005). Such teachers are able to survive and thrive again in the most challenging environments, largely because they hold the strength of the values (Fried, 1995; Hansen, 1995; Helsby et al., 1997; Day, 2004). Schools, especially in remote areas, have more challenging environments. Then teachers need to be recruited with higher values. For example, they are more concerned about how to improve education in rural areas and improve the quality of poor students through their own efforts instead of only concerning their salaries, which is the motivation for teachers to choose to teach in rural areas. The commitment of teaching comes from caring for children and the concept of education - what is the true meaning of education (Day & Kington, 2005).

On the second source of support, principals must foster "culture of trust" in a school. Day (2011) also said it was important to build "culture of trust" in schools. And the construction of "culture of trust" needs to be analyzed from multiple perspectives, including principal's trust in teachers, teachers' trust in principals, trust in colleagues, trust in students, parents and schools. According to the first source of support, to establish and develop a good school, teachers recruited by principals must have high values: ethics, professionalism, identity, motivation, commitment and resilience, so that the principal can fully trust the teacher recruited. Part of the basis for people to make trust judgments is shared values and attitudes (Tschannen-Moran, 2014). According to the relationship between "mutual trust" and "employee performance" mentioned before, only those teachers who fully feel the trust of the leaders, and they think their leaders are excellent and worthy of following, they will fully trust their leaders. If teachers trust their leaders but don't feel trusted, they may feel that their good intentions are not being properly rewarded, and therefore, on the principle of reciprocity, they will be reluctant to devote a lot of energy and effort (Gouldner, 1960). Fletcher (1998) also said that effective managers need to not only trust their subordinates, but also learn to make them feel trustworthy. Trust in each other creates an upward spiral of reciprocal trust and cooperation.This reciprocity cycle may be due to the continued exchange of positive behaviors that reinforce the existence of trust. Alternatively, reciprocity may be due to the trust response effect, in which people who feel trusted are also more likely to trust the other person (Bacharach et al, 2007). People have to feel that they are valuable, they are trusted, and they are respected. Day (2005) gives two examples: Pats is an early teacher whose professional growth and development benefits from the support of school managers, and the cooperative school culture that excellent leaders build, shape, and transform. It is in this positive school environment that the early teacher feels able to build her effectiveness, commitment and resilience, and go on to enjoy the achievements of her students and the progress of her career. Pat's adaptability has been further established and maintained because of some factors of the school environment. What’s more, for teachers to decide whether to go on teaching or not, the school leader's support is the most important factor (Day, 2017). The second example is Catherine, who is in the period of burnout, who feels that the senior leadership and structure of the school have made an important contribution to her success and survival. "The Senior Leadership Team (SLT) is reachable on both personal and school issues," she said. Knowing that they will be 100 percent supportive of their staff helps create "people-centred" school culture that, in her opinion, unites all staff as a team. Catherine is especially appreciative to the headmaster for her personal and professional support. It helped her through the difficulties. Teachers who have first entered rural areas need especially the support of the quality of the principals and the school environment , because the teaching conditions are more difficult than other schools, so that they could be totally loyal to the schools and reduce the turnover rate of teachers. In

addition, trust among colleagues is particularly important. Especially for school teachers working in socially and economically difficult circumstances, co-operation, mutual trust and support among colleagues are crucial to their morale, efficacy, well-being and effectiveness (Day & Leithwood, 2007; Peterson et al., 2008). Goddard et al.(2004) argued that this "strong sense of group competence" established expectations for success, and in turn encouraged "members to work resiliently towards goals". Some 75 per cent or more of resilient teachers believe supportive relationships with colleagues have a critical and positive impact on their ability to sustain their original career or teaching requirements (Day & Gu, 2010). And the principal has a great influence in improving the relationship between teachers and the staff. School leaders can play a basic and continuous role in driving change improvement and change by virtue of their status and power, as well as individual and collective influence (Day, 2017). The study found that the quality of school leaders and their long-term environmental-sensitive strategies are key to build and maintain teachers' commitment, participation and collective loyalty (Day, 2013). School leaders need to have and apply more interpersonal qualities and skills and extensive strategies than ever before (Day, 2014). Bryk & Schneider(2003) conducted a groundbreaking empirical study on the reasons for improving students' performance in primary schools, and found that "relationship trust" among teachers was a central factor. Trust can promote knowledge sharing, promote the teaching development (e.g. through peer coaching, curriculum learning and assessment processes), and is considered a key factor in successful teamwork, competence-building and the development of professional learning communities. The low level of trust among teachers constitutes a major obstacle to the establishment of new norms for these professions and collaboration. when teachers distrust their colleagues, whether due to lack of capacity, reliability, kindness or other factors, they are less likely to put their professional practices at risk by sharing teaching plans, reflective dialogue or peer observation (Tschannen-Moran, 2014). Over time, it is easy to affect the academic atmosphere of the whole school, resulting in the decline of the academic level of the whole school. Finally, a good culture of trust must involve every role, students, parents, teachers and principals. A school with trust as the implicit culture and orientation of the school will certainly be the mutual trust between teachers and school leaders, the mutual trust between teachers and the school, the mutual trust between teachers and the parents, and the mutual trust between the school and the community and the family. The culture of trust in schools can promote and improve a person's attitude and have a positive impact on the individual. Tschannen-Moran (2004)'s study of the effectiveness of primary school leaders also points out that the trust relationship between parents, teachers and leaders is the key to developing the performance in many areas of the school. Tschannen-Moran's study of primary school principals found trust to be the lubricant of organizational operations; without it, schools could experience conflicting excess friction and lack of progress in achieving their admirable goals. The school leader must take the lead and take the initiative to communicate with others. Sometimes, school leaders may be asked to show trust in colleagues who may not fully rewarded at least initially (Day, 2017). When teachers decompose their trust based on their susceptibility to another role group, they interpret each other's behavior in terms of benevolence, reliability, competence, openness, and honesty (Tschannen-Moran, 2014). Teachers are not passive actors in school, but co-builders of trust. As active professionals, teachers who feel excluded from important decisions react in a way that loses trust and undermines change (Seashore-Louis, 2007). But if teachers feel that they are co-builders of trust, they will greatly motivate themselves to do things and demonstrate their commitment to students, parents, leaders and schools. Teachers and principals pay attention to their students, and parents will trust teachers and schools more. Goddard et al.(2004) points out that trusting parental and teacher-student relationships promote normative and social relationships and help students move towards academic success.

3. Theoretical knowledge and methods

From the above analysis, we can see that to build a trust culture in the school, the first step to do is that the principal must first trust the teacher. Excellent principals have these characteristics:" pursuing common goals, empowering people, developing and maintaining a culture of collaboration, and promoting a process of coordinated development among teachers ". (Hargreaves, 1994). Among the four, "developing and maintaining a culture of collaboration" and "promoting a process of coordinated development among teachers" both belong to the school environment, which requires school leaders to make the best use of transformational leadership to create a culture of trust.

3.1 Transformational leadership

Transformational Leadership refers to the leadership through leadership appeal, leadership charm, personalized care and intellectual stimulation to make subordinates realize the importance of the tasks and responsibilities to motivate their higher-level needs, so as to maximize their potential to get the highest level of performance (Bass, 1998). There is a series of positive actions that leaders do to bring about "mutual trust" between leaders and teachers, thus bringing about a positive impact on "employee performance ". Bass further developed the research, defining transformational leadership as motivating subordinates' high-level needs, building an environment of mutual trust, and achieving results that exceed the original expectations by making subordinates realize the importance of the tasks they undertake. A leader with a transformational leadership optimizes member interactions within the organization through his own behavioral example, care for the needs of subordinates. At the same time, through the joint creation and promotion of organizational vision, within the organization to create an atmosphere of change, promote the organization in the process of efficient realization of organizational goals adaptive change (Gao Liping et al., 2011). In the research conducted by Gao Liping et al.(2011) against the team, it is also shown that transformational leadership has a very large impact on team effectiveness. At the same time, Meng Hui et al. (2005) also put forward a good idea of transformational leadership, because of its understanding of the signification of leaders themselves, it emphasizes the exemplary role of the leadership to the subordinates. First of all, the leaders pay attention to their own conduct, the courage to take responsibility and risk, and to give the subordinates a good model leading role, in the uncertain environment to effectively lead the subordinates to work together to overcome the difficulties. Meanwhile, pay attention to the needs of subordinates, provide challenging work and intellectual motivation to subordinates. Through these processes, the needs of superiors and subordinates are unified into the goals of the team, and the goals of superiors and subordinates are merged into one, and the team's superiors and subordinates work together to achieve common goals. That is, transformational leadership behavior can help subordinates to achieve the maximum level of performance by guiding them beyond their self-interest and instilling common organizational values into their subordinates.

3.2 Distributed leadership

The third characteristic of a good principal: "empowering people" requires a leader to use a distributed leadership. An important starting point for understanding distributed leadership is decoupling it from job authority. Harris (2004) states that distributed leadership focuses on hiring expertise anywhere within the organization, rather than simply seeking this through formal positions or roles. Harris refers to the English study of 10 English-language schools facing challenging environments, saying there should be "power redistribution", not just a process of "delegating leadership". Harris (2004) points that successful leadership recognizes the limitations of a single approach to leadership and adopts a form of leadership through cooperation and common work assignments. This is based on the undeniable fact that one "leader" is highly unlikely to improve a school without delegating responsibility for leadership to more than one person (Day, 2017). And school leaders want to develop a culture of trust, must use distributed leadership, because only trust teachers, principals will assign power to teachers, and teachers once involved in the distribution of power, then they will trust leaders more. Step 5 of Cott's "eight-step model" refers to empowering others to act according to their vision, "empowering" is "distribute the power". The aim is to improve the autonomy of teachers in setting development agendas and defining standards of practice and their potential value (Phil, 2017). The key to the success of distributed leadership is to "improve people's knowledge and skills in the organization, create a common culture of expectation around the use of these knowledge and skills..." and hold individuals accountable for their contribution to collective results (Day, 2017). If these issues are addressed and teachers gain confidence in areas they consider weak, they will gain personal confidence and are more likely to identify with the school's intentions and narratives (Coates, 2017). For schools in the 21st century, moving towards cooperative work is the only important change (Coleman, 2012). Hatcher (2005) found the reason why distributed leadership has become so important that achieving broader employee group participation is more effective in implementation of change . This suggests that distributed leadership is more like a cooperation, while leithwood et al. (2007) also mention that the core of a cooperative culture is a more equitable distribution of decision-making power among school members. In addition, in terms of the relationship between student achievement and

distributed leadership , many studies have shown that distributed leadership can effectively improve teacher development or student learning. A four-year study (leithwood et al., 2007) of 195 primary schools in the U.S. found that distributed leadership had a direct positive effect on academic capability and an important but indirect positive effect on students' achievement in math. Therefore, the proper distribution of leadership can be used as an effective way for schools to improve academic vitality and enhance students' academic performance. The study by leithwood et al. (2007) found that massing leadership among teachers has a positive effect on teacher effectiveness and student engagement. Silins et al. (2002) Research on more than 500 teachers and school principals also shows that student performance improves when leadership is distributed among school groups and when teachers are empowered in certain areas.

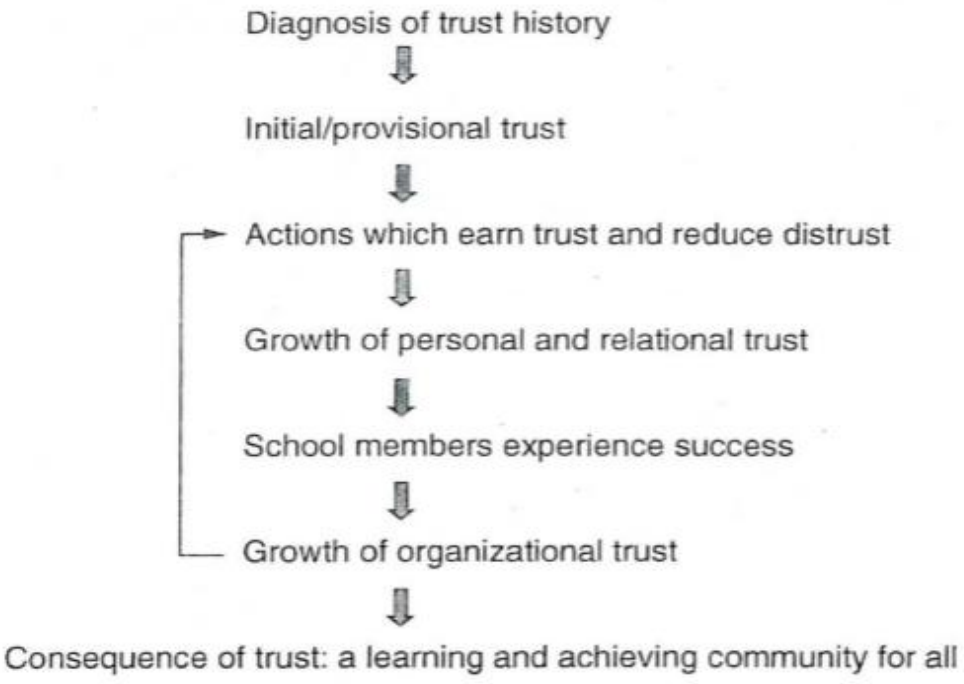

Figure 1 The progressive distribution of trust (Day, 2017)

3.3 Trust leadership

The success and extent of leadership and authority allocation depends on the development of trust and credibility (Day, 2011). Moreover, in the IMPACT project (Day et al., 2011), leadership responsibility allocation is related to trust development, which is incremental. This involves trust leadership. Compelling research evidence suggests that trust has a positive effect on employee behavior and attitudes, group function, and organizational performance levels (Day, 2017). Trust can promote knowledge sharing, promote teaching development, and is considered a key factor in successful teamwork, capacity building, and professional learning community growth. Dirks & Ferrin (2002) proposed three key points based on trust in leadership: first, teachers who trust leaders are more likely to feel committed, satisfied, and more likely to stay. Second, trust in leadership contributes to organizational change as it creates a cooperative environment in which people share knowledge. Third, the client can build trust by making the process fair and transparent, allocating resources and treating people fairly. Dirks & Ferrin (2002) collected a leadership trust study of 27000 people from 106 different research areas. They found that teachers' trust in leadership is based on mutual care and care. Teachers who trust their leaders more are less likely to quit, more likely to trust their information, and they seem to be more loyal to their school decisions than their principals. Teachers who trust their immediate superiors are more satisfied with their jobs, more loyal to their schools, and believe that they are treated more fairly in their processes and decisions. Teachers are more loyal to the school, more supportive of the organization, and feel that the leadership allocates resources fairly, treats others well and follows

procedures transparently. But it should be noted that trust as a practice and value cannot be imposed on subordinates and students. To cultivate, develop and maintain trust in others, leaders must show trust (Day, 2011). There is an obvious interaction between the quality or attribute of the leader and the development of trust (Day, 2011). But the leaders report that they have only allocated leadership to a small minority at the beginning of their term; it is only after years of building trust that they have distributed it more widely. We can identify a clear process based on trust that further develops over time and grows as the leadership allocation increases (Day, 2011). This trust is not "blind "; it is purely "ideological" or "principled"; it is based on close knowledge and long experience of cooperating with and observing others in various environments (Day, 2017). It's normal, but principals must use their initiative to use the trust leadership. Therefore, the gradual allocation of trust is a positive process that must be managed and led (Tschannen-Moran, 2004). Figure 1 (Day, 2017) illustrates the need for further action after each growth point of trust to win trust and reduce it. It is this kind of trust and trustworthy interaction that creates mutual trust and develops a culture of trust within the school.

Thus, the four characteristics of the excellent principals we have mentioned before: pursuing common goals, empowering people, developing and maintaining a culture of collaboration, and promoting a process of coordinated development among teachers, through the application of theory and method of transformational leadership, distributed leadership and trust leadership, we can make full use of new schools in rural areas to construct a sustainable school trust culture.

4. Application and Solution

As we have said before, leaders want to build "culture of trust" in school, first of all, their own values and abilities can make teachers trust. There is a clear interaction between the quality or attribute of the leader and the development of trust (Day, 2011). The findings suggest that effective regulators need to not only trust their subordinates, but also learn to make them feel trustworthy (Fletcher, 1998). Secondly, it is necessary to fully trust teachers with high values (ethics, professionalism, identity, motivation, commitment and resilience), and to use the transformational Leadership to make teachers aware of the responsibilities and the importance of the task, and to use the distributed leadership to distribute power to teachers. Even if supervisors have a high level of trust in their subordinates, if they rarely delegate authority to them, they may not actually feel that their superiors trust them, and therefore do not trust any potential benefits of achieving a high level of trust among their subordinates (Fletcher, 1998). Trust leadership can be used to better allocate leadership, so that trust and allocated leadership can interact with each other and supplement each other through time. Only when leaders and teachers deal with the "culture of trust" between them, parents and students will trust the principal, teachers and the whole school, and the "culture of trust" of the whole school will be constructed by mutual trust. So what concrete measures should principals use to build a "culture of trust" between themselves and their teachers?

4.1 Establish a fair and transparent system of evaluation, reward and punishment

Teachers are a knowledge group with a strong sense of equality and independent values. They are more sensitive to organizational fairness than ordinary people. For school teachers, whether the design, implementation and process of school rules and regulations are fair and transparent affects their trust in the school organization, and further affects their enthusiasm and devotion to work. At the heart of the concept of collaborative culture is a more equitable distribution of decision-making power among school members (Day, 2011).

Fair evaluation and reward and punishment system is the premise of competition and cooperation. It enables the school and its members to experience a sense of fairness in the process of judgment and distribution, thereby creating trust in the competition and cooperation carried out under such conditions. Fairness includes procedural fairness and result equity, the two are closely related to trust, the level of procedural fairness directly affects the degree of trust in the cooperative relationship, and affects the judgment of the two sides on the fairness of the result. In the process of evaluation and reward and punishment, school administrators should pay attention to the fairness of procedure and result, especially the fairness of procedure. In school management, we should reward trust and openness, not conservative, and punish cheating. The leader should do all the evaluation of teachers and rewards and punishments are well-founded, there are rules to follow. Any deviation and negligence in the evaluation process can be observed and supervised by the teacher, especially in terms of promotion of position (title). When the

leader's evaluation of the teacher is biased and unfair, and does not accord with the actual situation of the teacher's work, the teacher should be able to question it, and ask the leader to correct or re-evaluate it according to the system and the actual situation of his or her work. In this case, the teacher generates a trust in the rules and then evolves into trust in the leader and the whole school organization. On the contrary, if the evaluation and reward and punishment system is not open and opaque, teachers often doubt the fairness and justice of the leader and associate it with the personal preference of the leader, the trust is difficult to produce, and the enthusiasm of the work will be seriously frustrated.

4.2 Trust-based participation incentives

If the school leaders want to promote the realization of the school's organizational goals through trust, improve the organizational performance, stimulate the cohesion and creativity of the teachers' team and the enthusiasm of the individual, they must be fully empowered and decentralized, and let the teachers actively participate in the management and decision-making of the school affairs. Specific approaches to participation incentives can be divided into three categories: 1. Consultation. That is to mobilize teachers to put forward opinions and suggestions on school work. 2. Participation in management. Teachers can participate in administrative expansion meetings and staff representatives meetings, not only have the right to advise, but also part of the decision-making power. 3. Independent management. Teachers have greater autonomy and decision-making power within the assigned terms of reference. Employees who trust their leaders may feel comfortable and safe with the way the leader responds to their voice, thereby increasing the possibility that they are actually involved in expressing their views and ideas about workplace issues, other people's behavior, or the changes needed. However, if their trust in leaders is low, employees may find it too risky to give advice and worry about key work matters, which may lead them to choose to remain silent in the workplace (Gao Liping et al., 2011).

The major issues in the development of schools should be encouraged through democratic discussion, brainstorming and formation of systems to enable teachers to fully enjoy their democratic rights, encourage them to take part in the work in teaching, scientific research, industry and service fields as masters, cultivate teachers' sense of ownership, give advice to teachers, fully mobilize teachers' enthusiasm, and "align teachers' personal interests with the interests of school organizations ". Only true participation in decision-making can make the trusted party psychologically implicit about the meaning of trust. When employees become more involved in decision-making and are able to determine the content of their work, their trust increases and their motivation increases. The same is true of teachers. The teacher's labor is a cooperative and independent process. When it comes to cooperation, it is because training a useful talent or managing a class is not a teacher's credit, it requires the cooperation of teachers, the policy guidance and objective management of the leadership, and the coordination and cooperation of various departments. Sharing and collaboration provide opportunities for sharing and collaboration and promote a culture of trust (Day, 2011). But the teachers' teaching is an independent process, they do not want and do not allow to be disturbed by others and blind command. Both cooperation and decentralization cannot be separated from mutual trust between leaders and employees. Only when teachers and leaders fully trust each other, they will actively cooperate with each other, coordinate tacit understanding, become a cohesive group, and work together to achieve organizational goals.

4.3 Emotional stimulation based on trust

In today's "people-oriented management" concept gradually deeply rooted in the people, emotional motivation is an indispensable management method of the school, but also the most economical incentive means, through "strengthen the emotional communication with teachers, respect teachers, care for teachers, establish equal and cordial feelings with teachers, let teachers understand the care of leadership, the warmth of organization, so as to stimulate teachers' sense of identity and belonging to school organizations. Day (2011) also said that communication and understanding are crucial if relationship trust is to be developed. Based on the emotional basis of trust, is based on the mutual emotional pay for communication, sincere, mutual dedication as the core, which is not mixed with any human obligations of selfless trust. Respecting and valuing employees is considered a necessary condition for building "culture of trust" (Day, 2011). And this trust is the best sublimating agent of emotional motivation, which can burst out the strongest internal motivation.

First, leaders need to consider the diverse needs of teachers. Teachers are special mental workers, who have strong motivation for achievement, they care

about reputation, the priority of spiritual needs, require leaders to pay timely attention to their spiritual needs. On the one hand, school administrators should allocate financial expenditure reasonably, provide teachers with the necessary infrastructure, beautiful school appearance, comfortable office space, complete network facilities, and constantly create conditions to optimize and improve the material environment, and enhance teachers' sense of work comfort, pride and belonging. On the other hand, school leaders should strive to create a good teaching and scientific research environment and a harmonious interpersonal environment for teachers to fully meet the needs of teachers' knowledge exchange and social needs. In addition, in the case of soaring prices today, school leaders should also pay due attention to the material needs of teachers, care about the living conditions of teachers and family difficulties.

Secondly, leaders need to affirm the teacher's ability to work and express confidence. Compared with other workers, teachers have a strong desire to show themselves. They care about their own value and the realization of the value of their educational products, and expect to be recognized by the leadership and society. This recognition from others will often give them unparalleled courage and great encouragement, and then will turn this external incentive into a self-motivation from the heart, but also stimulate teachers' sense of belonging to the school and loyalty to the organization. School administrators should be well-versed in the teacher's psychology, show due appreciation and trust in the teacher's ability, and make the best of his ability.

Third, leaders should be in direct contact with your teacher. Emotional intimacy among school members is an important factor in determining the strength of mutual trust. The regular direct contact of superiors and subordinates is conducive to the cultivation of common cognition, the enhancement of mutual familiarity and the establishment of trust relations. School leaders should always pay attention to teachers' work, life, study, and strive to improve the treatment of teachers; for some reasonable requirements of teachers, school leaders must pay attention to and seriously solve; for teachers to some of the school's practices confused or puzzled, school leaders should be patient to explain in time. Only in this way, teachers will be responsible, enterprising and motivated to get the maximum degree of mobility, they will regard work as a kind of happiness and pleasure. At the same time, teachers should also take the initiative to contact and communicate with the leaders, report the work situation in time, reflect the problems existing in the work, and give the leaders strong support and understanding in the work.

In a word, the establishment of trust is a long-term process of mutual communication and emotional connection. In the actual teaching management activities, it is difficult to form a trust atmosphere and trust relationship from superiors to subordinates, which requires positive, optimistic and cooperative attitude of all people in the school, and more attention from the leaders managers.

5. Limitations

Although trust can solve many problems in education management, it still has many limitations. First, mutual trust takes a long time to accumulate. In the IMPACT project (Day et al. ,2011), the distribution of leadership responsibilities is related to the growth of trust. It is progressive, starting with the involvement of some trusted senior colleagues, to building informal trust through collaboration, and it becomes more inclusive. Over time, the establishment of trust and the distribution of leadership responsibilities and roles grow and become key to successful leadership in all situations. The establishment of trust is both the "glue" of productivity cooperation growth and the "lubricant" of its process. Trust, the allocation of leadership, and the growth of organizational capacity have all developed through combination and accumulated applications. Mutual trust is not achieved overnight, it needs to be tested through time. Secondly, some teachers may disguise themselves, as we have said before, leaders need to trust teachers with higher values (ethics, professionalism, identity, motivation, commitment and resilience), but often some teachers, in order to show their own trust, will package and disguise themselves in a variety of ways, which requires leaders to have a high ability to identify and distinguish, but also need time to slowly see whether their teachers have high values and abilities. Any new vision of school activities requires "down-to-earth" advocates, not just action on the surface (Brown & Greany, 2017). Finally, the leader must grasp the degree of giving the teacher trust, the optimal trust is a balanced behavior, because trust too much and too little are dangerous (Tschannen-Moran, 2014). Leaders need to trust their employees but cannot trust their employees too much. Leaders who give too much power and trust to teachers will lead to some teachers' abuse of power. Leaders who do not give power and

trust to teachers will lose the trust of the teachers.

6. Conclusion

Trust is crucial to building and developing a good school. Among them, the school's "culture of trust" needs to be analyzed from many aspects and angles: the trust of the principal to teachers, the trust of teachers to the principal, the trust between the colleagues, the trust between students, parents and the school. Only if every aspect achieves mutual trust, the whole school's "culture of trust" will flourish and develop healthily, every link is indispensable. In one link, the "mutual trust" between the principal and teachers is crucial, and the mutual trust between superiors and subordinates is related to employee performance, which is the basis of whether the school's "culture of trust" can be built. The school leader needs to take the first step, and the school leader has a long way to go.

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Artificial Intelligence Anxiety and Entrepreneurial Intentions among University Students: The Sequential Mediation of Mindset and Self-Efficacy

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Abstract： Objective To examine the impact of Artificial Intelligence (AI) anxiety on entrepreneurial intentions among university students, proposing a chain-mediating model involving entrepreneurial mindset and self-efficacy. **Methods** Based on a sample of 358 Chinese university students, structural equation modeling (SEM) was conducted using AMOS to analyze the relationships between AI anxiety, entrepreneurial mindset, self-efficacy, and entrepreneurial intention. **Results** (1) AI anxiety has a marginally significant positive effect on entrepreneurial intention (β = 0.115, p = 0.052); (2) entrepreneurial mindset mediates this relationship with a significant indirect effect (-0.055); (3) entrepreneurial self-efficacy also mediates the relationship, with an effect size of 0.148; and (4) entrepreneurial mindset and self-efficacy jointly form a chain-mediating pathway, contributing a substantial mediating effect (0.191).**Conclusion** Entrepreneurial mindset and entrepreneurial self-efficacy play a chain-mediating role in the relationship between AI anxiety and entrepreneurial intention. These findings support the integration of AI into entrepreneurship education and practice to harness its potential while addressing student concerns.

Keywords：Artificial Intelligence Anxiety；Entrepreneurial Intention；Entrepreneurial Mindset；Entrepreneurial Self-efficacy

1 Introduction

With the rapid progress of artificial intelligence (AI), employment structures and economic paradigms are undergoing profound shifts. On the one hand, AI contributes to market analysis, product innovation, and operational efficiency, (Davidsson & Sufyan, 2023; Giuggioli & Pellegrini, 2023) It also helps lower the threshold for entrepreneurship, strengthens individuals' sense of efficacy, supports personalized learning, and thereby opening up new opportunities for entrepreneurial activity (Boateng et al., 2024; L. Chen et al., 2024; Lin & Chen, 2024).

On the other hand, studies estimate that around 60% of jobs in developed countries may be replaced by AI, with significant job displacement risks also looming over emerging and low-income economies—exerting considerable pressure on youth employment (Adigwe et al., 2024). This pressure may lead university students to experience anxiety about artificial intelligence (Wang & Wang, 2022).

In this context, entrepreneurship is increasingly seen as a crucial strategy for addressing unemployment and generating new job opportunities (Bae, 2021; Mukhtar et al., 2021) Psychological factors are crucial for entrepreneurship, as they significantly influence entrepreneurial intentions and behaviors (Antoncic & Antoncic, 2023). The main factor to anyone to become as an entrepreneur is mindset (Aima et al., 2020). A strong entrepreneurial mindset not only nurtures innovation and problem-solving abilities (Akbari et al., 2024; Rustiana et al., 2022), but also enhances entrepreneurial self-efficacy, reshapes defensive coping strategies, and eventually fosters entrepreneurial intention (Caputo et al., 2025).

However, empirical research on how AI anxiety affects university students' entrepreneurial intentions remains limited. To address this gap, the present study aims to explore the influence of AI anxiety on entrepreneurial intention, with the goal of providing theoretical insights and practical guidance for the

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integration of AI technologies into entrepreneurship education.

2 Theoretical Background

2.1 The Relationship Between Artificial Intelligence Anxiety and Entrepreneurial Intention

Entrepreneurial intention refers to a psychological state that directs attention, experience, and behavior toward entrepreneurial goals (Bird, 1988). It is considered the most direct predictor of future entrepreneurial behavior (Fayolle & Liñán, 2014).

AI anxiety refers to individuals' emotional reactions to the possible negative consequences of AI technologies, especially concerns surrounding the unpredictability and risks of technological advancement (Wang & Wang, 2022).

With growing concerns that AI may replace jobs or increase uncertainty, individuals are experiencing heightened anxiety (Wang & Wang, 2022). Research shows that when anxiety about unemployment—an element of AI anxiety—rises, people are more likely to view entrepreneurship as a way to cope with uncertainty, thus showing stronger entrepreneurial intentions (Ersari, 2023; Uçar et al., 2024). On this basis we put forward the hypothesis 1: AI anxiety positively predicts entrepreneurial intention among university students.

2.2 The Mediating Role of Entrepreneurial Mindset

Among the various factors influencing university students' entrepreneurial intention, individual factors are considered the most critical—particularly the extent to which students endorse an entrepreneurial mindset (Xu & Huang, 2024). Entrepreneurial mindset—that is, the underlying beliefs individuals hold about their potential to grow and adapt within entrepreneurial contexts (Burnette et al., 2020). The entrepreneurial mindset has attracted widespread global attention (Al-Qadasi et al., 2024; Mussaiyib & Chandra Pradhan, 2024; Sá et al., 2024), and existing studies have demonstrated that it significantly enhances students' entrepreneurial intention (Handayati et al., 2020; Zhang et al., 2022). Although there is currently no direct evidence confirming the impact of AI anxiety on the entrepreneurial mindset, AI anxiety has been shown to negatively affect innovation orientation. It may lead individuals to resist new technologies, thereby reducing both their innovative behavior and entrepreneurial intention(Öztirak, 2023). Accordingly, the hypothesis 2 is proposed: Entrepreneurial mindset mediates the relationship between AI anxiety and entrepreneurial intention.

2.3 The Mediating Role of Entrepreneurial Self-Efficacy

Entrepreneurial self-efficacy refers to an individual's confidence in their entrepreneurial abilities(Neneh & Dzomonda, 2024). It is the closest and most direct predictor of entrepreneurial intention and behavior (Neneh, 2022) and has a significant positive effect on individuals' entrepreneurial intention(Gonzalez-Tamayo et al., 2024; Wardoyo et al., 2025). Entrepreneurial self-efficacy serves as a crucial psychological foundation for entrepreneurs to cope with risks, learn and recover from failure, identify new opportunities, and sustain entrepreneurial activities(Zhao & Wibowo, 2021). Interaction with artificial intelligence directly influences self-efficacy, which in turn affects learning achievement(Liang et al., 2023). This suggests that the use of AI in the entrepreneurial domain may enhance students' entrepreneurial self-efficacy. AI anxiety may motivate students to more actively seek assistance and resources, thereby strengthening their entrepreneurial capabilities and intentions (Ullah, 2024). Based on the above reasoning, hypothesis 3 is formulated as follows: Entrepreneurial self-efficacy mediates the relationship between AI anxiety and entrepreneurial intention.

2.4 The Chain Mediating Role of Entrepreneurial Mindset and Entrepreneurial Self-Efficacy

Existing research has revealed a significant negative correlation between entrepreneurial mindset and inhibitory anxiety—in other words, individuals with higher levels of inhibitory anxiety tend to exhibit lower levels of entrepreneurial mindset(Florin Stănescu & Constantin Romașcanu, 2024). A substantial body of research has indicated that entrepreneurial mindset, cultivated through systematic theoretical instruction and practical experience, can effectively enhance students' entrepreneurial self-efficacy (Amani et al., 2024; Kurczewska & Białek, 2014). This suggests that AI anxiety may suppress entrepreneurial mindset, thereby reducing entrepreneurial self-efficacy and ultimately weakening students' entrepreneurial intention. Thus, Hypothesis 4 is advanced: Entrepreneurial mindset and entrepreneurial self-efficacy sequentially mediate the relationship between AI anxiety and entrepreneurial intention.

3 Research Methodology

3.1 Participants

The present study employed a stratified sampling method to conduct a survey among university students. A total of six universities in Hubei Province, China, were selected. The survey was administered via the online platform Wenjuanxing, and participants completed the questionnaire voluntarily after being fully informed of the purpose and content of the study.

A total of 416 responses were collected, among which 358 were deemed valid after data screening, resulting in an effective response rate of 86%. Basic demographic information of the participants is presented in Table 1.

Table 1. Basic information of subjects (n=358)

Variable	Category	Frequency	Percentage（%）
Gender	Male	154	43.0
	Female	204	57.0
Grade	Freshman	71	19.8
	Sophomore	106	29.6
	Junior	127	35.5
	Senior	54	15.1

3.2 Measurement Instruments

3.2.1 Artificial Intelligence Anxiety Scale

AI anxiety was measured using a six-item scale adapted by Chen et al. (2025), originally developed by Wang and Wang(2022). Responses were rated on a seven-point Likert scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”), with higher total scores indicating greater levels of AI anxiety. In the present study, the scale demonstrated excellent internal consistency, with a Cronbach’s α of 0.930.

3.2.2 Entrepreneurial Mindset Scale

The entrepreneurial mindset scale was revised based on the scale developed by Burnette et al.(2020). The scale includes four items. All items were rated on a 7-point Likert scale (1 = "strongly disagree," 7 = "strongly agree") using positive scoring, with higher scores reflecting a stronger entrepreneurial mindset. The Cronbach’s α coefficient for this scale in the current study was 0.925, indicating strong reliability.

3.2.3 Entrepreneurial Self-Efficacy Scale

Entrepreneurial self-efficacy was measured using a scale developed by Li(2020). The localized version comprises four items, each rated on a 5-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"), using positive scoring. The scale demonstrated acceptable reliability, with a Cronbach’s α of 0.879.

3.2.4 Entrepreneurial Intention Scale

Entrepreneurial intention was measured using a revised version of the scale by Guo(2022). Five localized items were selected and evaluated using a 5-point Likert scale (1 = "strongly disagree," 5 = "strongly agree"), with higher scores indicating stronger entrepreneurial intention. The Cronbach’s α coefficient for this scale in the present study was 0.895.

3.3 Data Analysis

Data analysis was conducted using AMOS 27.0. Descriptive statistics and Pearson correlation coefficients were first calculated to assess the data distribution and relationships among variables. Structural equation modeling (SEM) was then applied to test the hypothesized model, evaluating both direct and indirect effects. Model fit was assessed using standard indices including χ^2, CFI, TLI, RMSEA, and SRMR. Bootstrapping with 5,000 resamples was performed to examine the significance of mediation effects. A significance level of $p < 0.05$ was adopted for all analyses.

4.Ressult

4.1 Descriptive and Correlational Analysis of Key Entrepreneurial Variables

The study examined four core variables: artificial intelligence anxiety (AIA), entrepreneurial mindset (EM), entrepreneurial self-efficacy (ESE), and entrepreneurial intention (EI). As shown in Table 2, the mean AIA score was 4.04 (SD = 0.87) on a 7-point scale, reflecting a moderate level of anxiety. EM averaged 4.33 (SD = 1.00), suggesting a generally positive entrepreneurial attitude among participants.

In contrast, ESE (M = 2.87, SD = 0.62) and EI (M = 2.81, SD = 0.66), measured on a 5-point scale, were slightly below the midpoint, indicating moderate levels of self-efficacy and intention.

Correlation results showed that AIA was negatively associated with EM ($r = -0.264$, $p < 0.01$),

but weakly positively related to both ESE ($r = 0.227$, $p < 0.01$) and EI ($r = 0.153$, $p < 0.01$). EM was positively correlated with ESE ($r = 0.399$, $p < 0.01$) and EI ($r = 0.317$, $p < 0.01$). ESE had the strongest correlation with EI ($r = 0.497$, $p < 0.01$), highlighting its key role in shaping entrepreneurial intention.

These results suggest that AIA may influence EI through complex pathways, which will be further examined in the following structural model analysis.

Table 2. Descriptive Statistics and Correlation Matrix

Variable	Mean	SD	AIA	EM	ESE
AIA	4.04	0.87	-	-	-
EM	4.33	1.00	-0.264**	-	-
ESE	2.87	0.62	0.227**	0.399**	-
EI	2.81	0.66	0.153**	0.317**	0.497**

Note. **：$p < 0.01$ (two-tailed), statistically significant

4.2 Confirmatory Factor Analysis Results

The study conducted confirmatory factor analysis (CFA) to examine the reliability and validity of the latent constructs. As shown in Table 4, the factor loadings of the six observed variables for AIA ranged from 0.80 to 0.90. The composite reliability (CR) was 0.931, and the average variance extracted (AVE) was 0.693, all exceeding the critical threshold of 0.60, indicating good internal consistency and convergent validity of the AIA scale. For EM, the four observed variables had factor loadings between 0.85 and 0.90, with a CR of 0.927 and an AVE of 0.759, demonstrating a reliable scale structure. The ESE scale showed factor loadings ranging from 0.78 to 0.84, a CR of 0.880, and an AVE of 0.647, meeting reliability requirements. The EI scale's five observed variables had loadings between 0.73 and 0.84, with a CR of 0.897 and an AVE of 0.635, indicating good scale reliability and validity. Overall, all observed variables had high factor loadings, and the CR and AVE values met psychometric standards(Hair et al., 2021), suggesting the data are suitable for subsequent structural equation modeling.

Table 3. Reliability Indicators of Latent Variables

Variable	Observed variable	Loading coefficient	CR	AVE
AIA	AIA1	0.80	0.931	0.693
	AIA2	0.82		
	AIA3	0.82		
	AIA4	0.90		
	AIA5	0.82		
	AIA6	0.84		
EM	EM1	0.88	0.927	0.759
	EM2	0.85		
	EM3	0.90		
	EM4	0.85		
ESE	ESE1	0.80	0.880	0.647
	ESE2	0.84		
	ESE3	0.78		
	ESE3	0.81		
EI	EI1	0.84	0.897	0.635
	EI2	0.82		

EI3	0.73
EI4	0.82
EI5	0.78

4.3 Structural Model Validation Results

The study employed structural equation modeling (SEM) to examine the mechanisms influencing entrepreneurial intention. The chi-square statistic (χ^2) was 150.625 with 146 degrees of freedom (p = 0.380), indicating a good fit between the model and the data. The comparative fit index (CFI), normed fit index (NFI), and incremental fit index (IFI) were 0.999, 0.969, and 0.999, respectively, demonstrating significant improvement over the null and saturated models. The root mean square error of approximation (RMSEA) was 0.009, below the threshold of 0.08, and the standardized root mean square residual (SRMR) was 0.031, suggesting minimal discrepancy between predicted and observed values. Collectively, these indices indicate a good overall model(Kline, 2023), supporting further analysis of the path relationships among variables.

The structural equation modeling results for entrepreneurial intention are illustrated in Figure 1 and detailed in Table 4. The results indicate that the direct effect of AIA on university students' EI showed a marginally significant effect (β = 0.115, p = 0.052), which suggests a potential trend but does not meet the conventional threshold for statistical significance (p < 0.05). Therefore, H1 was not supported.

AIA had a significant negative direct effect on EM (β = -0.287, p < 0.001), suggesting that individuals with higher levels of AI anxiety tend to exhibit a more negative EM. EM exerted significant positive direct effects on ESE (β = 0.565, p < 0.001) and EI (β = 0.190, p < 0.01). AIA also had a significant positive direct effect on ESE (β = 0.409, p < 0.001). The direct effect of ESE on EI was the most pronounced (β = 0.455, p < 0.001).

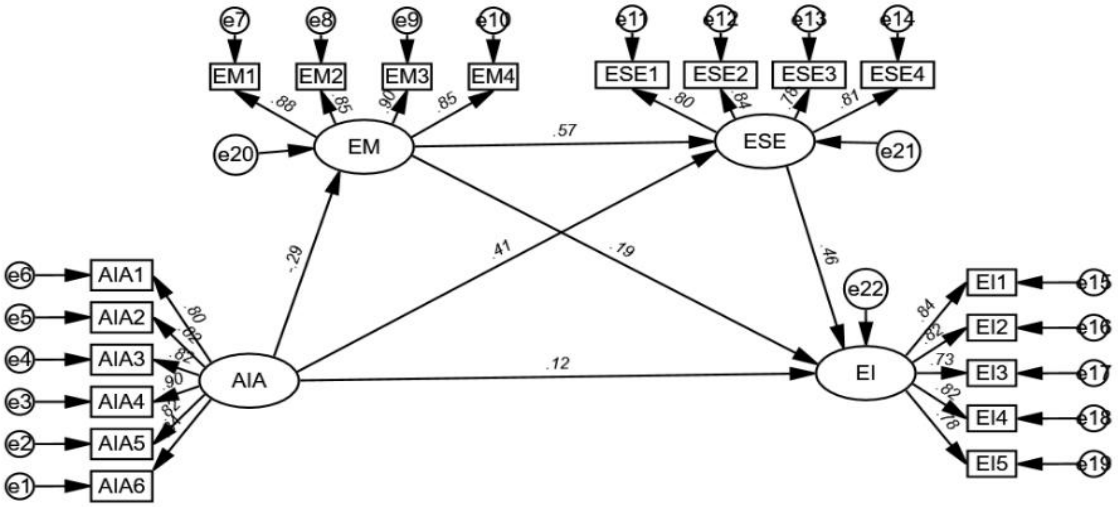

Figure 1. Structural Equation Model Diagram
(Note: represents error terms; data are standardized values.)

Table 4. Direct Effects Among Latent Variables

Causal Path	B (Estimate)	β (Std.)	S.E.	C.R.	P
EM ← AIA	-0.307	-0.287	0.060	-5.123	***
ESE ← EM	0.348	0.565	0.036	9.651	***

ESE ← AIA	0.270	0.409	0.037	7.298	***
EI ← ESE	0.547	0.455	0.084	6.501	***
EI ← EM	0.141	0.190	0.049	2.889	0.004
EI ← AIA	0.091	0.115	0.047	1.940	0.052

Note.***：P < 0.001；

The study further examined the indirect effects among variables using the Bootstrap method (see Table 5). The results indicated that AIA exerted a significant negative indirect effect on ESE through EM (standardized coefficient = -0.162, 95% CI = [-0.162, -0.067]), suggesting that AIA reduces individuals' entrepreneurial self-efficacy by weakening their EM. Meanwhile, AIA also had a significant negative indirect effect on EI via EM (standardized coefficient = -0.055, 95% CI = [-0.082, -0.015]), thus supporting Hypothesis 2 that entrepreneurial mindset partially mediates the relationship between AI anxiety and entrepreneurial intention.

Interestingly, AIA showed a significant positive indirect effect on EI through entrepreneurial self-efficacy (standardized coefficient = 0.186, 95% CI = [0.096, 0.216]), indicating a dual-path mechanism where positive and negative indirect effects coexist, thereby supporting Hypothesis 3. Taken together with the direct and indirect effects, these findings confirm Hypothesis 4 that EM and ESE serve as sequential mediators in the relationship between AIA and EI. Additionally, the strongest indirect effect was observed from entrepreneurial mindset to entrepreneurial intention through entrepreneurial self-efficacy (standardized coefficient = 0.256, 95% CI = [0.130, 0.263]), demonstrating that entrepreneurial mindset not only directly influences entrepreneurial intention but also indirectly promotes entrepreneurial intention by enhancing self-efficacy.

Table 5 Indirect Effects Among Latent Variables

Causal Path	B(Estimate)	β(Std.)	Bootstrap 95% CI (Lower limit，Upper limit)	P
ESE ← EM←AIA	-0.107	-0.162	(-0.162, -0.067)	***
EI ← EM← AIA	-0.043	-0.055	(-0.082, -0.015)	**
EI← ESE← AIA	0.148	0.186	(0.096, 0.216)	***
EI ← ESE← EM	0.191	0.256	(0.130, 0.263)	***
EI←ESE←EM←AIA	-0.059	-0.074	(-0.094, -0.035)	***

Note.***：P < 0.001；**：P < 0.05

5. Discussion

The results reveal the complex role of AI anxiety in shaping entrepreneurial intentions among university students, particularly highlighting its dual impact on entrepreneurial mindset and entrepreneurial self-efficacy. In terms of direct effects, AI anxiety significantly weakens the entrepreneurial mindset, suggesting that when individuals are confronted with technological substitution and career uncertainty brought by AI, they are more likely to engage in cognitive threat assessments, which in turn suppresses their entrepreneurial mindset (Cebeci et al., 2019).

At the same time, AI anxiety exhibits a significant positive effect on entrepreneurial self-efficacy. While this result may appear paradoxical, it reflects the dual nature of anxiety as an emotional state. Under certain conditions, individuals may internalize the pressure triggered by AI as a motivation for growth, thereby proactively improving their own abilities to cope with change (Bandura, 1999). Within the context of the AI wave, some students may actively acquire new skills and seek new business opportunities, viewing

technological disruption itself as a window for entrepreneurship (Davidsson & Sufyan, 2023).

The significant positive impact of entrepreneurial mindset on both self-efficacy and entrepreneurial intention further validates the theoretical proposition by Krueger et al. (2024), which emphasizes the role of positive cognition in activating entrepreneurial behavior. Studies have shown that students who hold an open, exploratory, and optimistic outlook on the future are more likely to believe in their ability to succeed in entrepreneurship and thus develop a concrete intention to act (Amani et al., 2024; Kurczewska & Białek, 2014). This pathway mechanism reinforces the central role of cognitive variables in the formation of behavioral intentions and also suggests that, within the broader context of AI transformation, psychological resources (such as mindset and self-efficacy) may be more predictive of entrepreneurial behavior than objective conditions (such as capital or experience).

From the perspective of mediating pathways, this study confirms a chained mediation structure involving entrepreneurial mindset and entrepreneurial self-efficacy, highlighting the pivotal roles of these two variables in the mechanism of AI anxiety. On the one hand, AI anxiety undermines entrepreneurial mindset, thereby indirectly reducing self-efficacy and entrepreneurial intentions. On the other hand, it may also activate self-enhancement mechanisms in certain individuals, which boosts self-efficacy and, in turn, entrepreneurial intentions. This dual-pathway mechanism not only aligns with the extended model of emotion regulation theory (Gross, 2001; Gross & Thompson, 2007), but also partially explains why the direct effect of AI anxiety on entrepreneurial intention only reached marginal significance ($\beta = 0.115$, $p = 0.052$). This may be due to the offsetting effects of two opposing pathways: one characterized by anxiety-induced withdrawal and avoidance, and the other by efficacy-driven motivation.

In addition, the study by Lee and Jung (2021)on the relationship between types of anxiety and entrepreneurial mindset provides theoretical support for our findings. Their research indicated that inhibitory anxiety exerts a significant negative effect on entrepreneurial mindset (path coefficient = -0.39), whereas prospective anxiety shows a positive effect (path coefficient = 0.35). This underscores the notion that anxiety is not a unidimensional emotional response; different types of anxiety are associated with distinct psychological mechanisms and behavioral tendencies.

Therefore, AI anxiety does not exert a uniform influence across all contexts, and the complex relationship between anxiety and entrepreneurial intention suggests the possible presence of unmeasured moderating variables or boundary conditions. Future research should further refine the dimensional structure of AI anxiety and adopt longitudinal designs to explore its dynamic evolution over time. Only through more granular theoretical modeling and time-lagged investigations can the psychological pathways through which AI anxiety shapes entrepreneurial intention be fully understood.

6. Conclusion

This study employed structural equation modeling and related techniques to explore the relationships among AI anxiety, entrepreneurial mindset, entrepreneurial self-efficacy, and entrepreneurial intention in a sample of university students. The results show that AI anxiety exerts a significant negative direct effect on entrepreneurial mindset, a significant positive direct effect on entrepreneurial self-efficacy, and a marginally significant effect on entrepreneurial intention. Entrepreneurial mindset significantly enhances both self-efficacy and entrepreneurial intention, while entrepreneurial self-efficacy itself serves as a robust predictor of entrepreneurial intention.

Further analysis reveals a dual-pathway mechanism underlying the impact of AI anxiety. On one hand, heightened anxiety can dampen entrepreneurial mindset, thereby weakening self-efficacy and intention. On the other hand, it can also act as a motivational trigger that indirectly fosters intention through strengthened self-efficacy. These findings support a chain mediation model in which entrepreneurial mindset and self-efficacy play pivotal roles.

In terms of theoretical contribution, this research is among the first to incorporate AI anxiety into the entrepreneurial intention framework, offering a nuanced view of how emotional responses to technological change shape entrepreneurial cognition and behavior. By bridging constructs from the Technology Acceptance Model and entrepreneurial cognition theory, the study extends existing models and opens new avenues for future research.

From a practical perspective, the findings offer guidance for both aspiring entrepreneurs and educators.

Individuals facing uncertainty in the AI era may benefit from strategies that channel anxiety into proactive learning and skill development, particularly in areas related to emerging technologies. For educators, integrating AI-related content into entrepreneurship education may help students develop a more resilient entrepreneurial mindset and higher self-efficacy—both of which are essential to fostering strong entrepreneurial intention.

Although the study offers both theoretical and empirical implications, it still has some limitations that future authors should address. The sample is limited in its demographic and regional scope, which may restrict the generalizability of the findings. Moreover, its cross-sectional design prevents conclusions about causality or changes over time. Future research would benefit from longitudinal approaches and more diverse sampling to further investigate the dynamic and context-sensitive nature of these psychological mechanisms.

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Research on the Development Strategy of Sanya Sports Tourism in the Background of "Event + Travel "

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Abstract: With the rapid development of China's economy and the success of large-scale sports, tournaments, and travel have become a sought-after new way of sports tourism in today's era. Large-scale sports events can not only attract fans of the sport and sports stars to watch the game but also can drive the organizing city and other cities around the booming development of the tourism industry. Therefore, this paper mainly discusses the current situation, advantages, disadvantages, opportunities and threats (SWOT) of the development of Sanya's sports tourism industry in the context of the deep combination of events and travel, and puts forward corresponding development countermeasures accordingly.

Keywords: sports tourism, events, tourist resources, large-scale sports events.

1.Overview of Tourism Resources in Sanya City

Sanya City is located in the southernmost part of Hainan Island, belonging to the tropical maritime monsoon climate, with an average annual temperature of 27 ℃ (80.6°F). The geographical location as well as the climate environment make Sanya a famous tourist destination, attracting a large number of domestic and foreign tourists to travel to the island. In addition, Sanya City has several well-known tourist attractions, including 5A-level scenic spots such as Yalong Bay Tropical Paradise Forest Park, Tianya Haijiao Excursion Area, Nanshan Cultural Tourism Area, Nanshan Daxiaodongtian, Penang Valley Lemiao Cultural Tourism Area, Wuzhizhou Island, etc.; 4A-level scenic spots such as Luhuitou Peak Park, Xidao Marine Cultural Tourism Area, Phoenix Ridge Oath of the Sea and Mountain Scenic Spot, etc.. Rich tourism resources provide a solid foundation for the development of sports tourism in Sanya City.

2.Current Situation of the Sports Tourism Market in Sanya City

The 15th Hainan Tour International Cycling Race took place in Sanya in 2024, fueling the momentum for the summer tourism market. In September, China's Bodybuilding star Sanya line activities for the National Day holiday warm-up diversion; in October 2024 Hainan Golf Open European Tour Challenge, 2024 International Tourism Island Windsurfing Grand Prix held in Sanya; in November, the twelfth Hainan Golf Open European Tour Challenge, 2024 International Tourism Island Windsurfing Grand Prix held in Sanya; in November, the twelfth Sanya City Sports Tourism Market. In October, the 2024 Hainan Golf Open European Tour Challenge and the 2024 International Tourist Island Windsurfing Grand Prix were held in Sanya. Nowadays, "Event + Tourism" has become an important way to promote the high-quality development of tourism and showcase the city's image. Sanya, with its rich tourism resources, is not only a popular leisure and vacation city, but also suitable for hosting a variety of sports events. Therefore, how to organize more high-quality events, transforming sports traffic into development increment, and creating a new business card for the integrated development of tourism, culture and sports is the direction that Sanya focuses on and continues to make efforts.

3.Analysis of the Development Advantages

Sanya City is located in the southernmost tip of Hainan Island, the four seasons are warm like spring, and the sea temperature is suitable for swimming and other water activities, providing superior natural conditions for the development of sports tourism. Secondly, Sanya's superior natural environment is not only conducive to the organization of events, but also to long-term residence. Mainland and overseas residents often choose to live on the island during the winter to experience the charm of the view of coconut and the sea. Whether it is diving, surfing, sailing, windsurfing, beach volleyball or beach soccer, these programs are suitable for all seasons, attracting a large number of outdoor sports enthusiasts who love the sun

and the beach. In addition, there is a unique tropical rainforest scenery, hiking, adventure, cross-country, and other sports tourism programs can be planned, thus enriching the sports tourism product categories. As a famous tourist destination in China, Sanya has a complete tourism infrastructure, and the hotel industry is very prosperous, with high-end luxury hotels and affordable bed and breakfasts to meet the accommodation needs of tourists of different grades. Catering is also varied, a blend of flavors from all over the country and delicious local specialties. Transportation is very convenient. Phoenix International Airport is densely populated with flights and closely connected to many major cities at home and abroad. And the city's transportation network continues to improve with a well-connected public transportation system and convenient car rental services, which makes it easy for tourists to get to various sports and tourism locations. At the same time, tourism services are mature, with travel agencies, tour guides, tourist shopping and other mature services, providing a full range of services for sports tourism.

Ethnic characteristic tourism resources are abundant in Sanya. Sanya is a city of multi-ethnic integration and settlement. Scenic spots such as Penang Valley Li and Miao Cultural Tourism Area and Yanoda Tropical Rainforest are the embodiment of Li culture. These scenic spots are the living fossils for understanding the aboriginal culture of Hainan Island. And they have preserved the most primitive Li flavor, for example, Li Chai Dance, Yazhou Folk Songs, and Li traditional spinning, dyeing, weaving and embroidery techniques. All of them are national intangible cultural heritages. The Yetian Ancient Village Scenic Spot showcases the Miao flavor, preserving the ancient culture and development trajectory of the Miao forefathers. Visitors can experience the hospitality of the Miao people to other ethnic groups through the Miao songs and dances, as well as the classic culture embedded in the songs and dances. In addition, "March 3" is also an important festival for the Li and Miao people in Hainan. On this day, the rod playing gyro, bamboo dance, climbing coconut trees, and other traditional sports and cultural activities to show the form of national characteristics of the activities. These activities not only allow tourists to understand the daily life of the Li-Miao people, cultural practices, but also effectively promote the development of sports tourism in Sanya. These activities set up and promote Sanya's unique brand image of sports tourism.

Policies support the development of sports tourism. Sanya actively organises a variety of large-scale sports activities, such as road cycling races, big sailboat races, Hainan Golf Open, etc., and has accumulated a wealth of experience in organizing events, with strong tournament security capabilities. From the preparation of tournament venues and facilities to tournament safety and security, tournament publicity and promotion, etc.. From preparing competition venues and facilities to ensuring competition safety and promoting competitions, relevant workers should vigorously enhance the city's sports atmosphere and lay the foundation for the development of sports tourism. This will attract competition enthusiasts to come and watch or participate in competitions, thereby promoting related tourism consumption. According to the 'Sanya City Sports Tourism Development Master Plan (2021-2035)', the primary objective of this plan is to support the creation of the 'Hainan Province National Sports Tourism Demonstration Zone' and the 'National Sports Consumption Pilot City.' The goal is to establish Sanya as a 'Sports Tourism Demonstration City,' a 'Tropical Coastal Leisure and Resort Sports Tourism Zone,' and an international sports event hub. Through the integration, optimisation, and innovation of policies, resources, industries, and talent, the plan aims to further clarify the development goals and positioning of Sanya's sports tourism sector, establish its spatial layout and functional structure, systematically optimise and design its product system, and expand the development and consumption structure of the sports tourism industry. Finally, it seeks to comprehensively explore the supporting systems and policy measures required for development, providing strategic guidance and phased action plans for the development of Sanya's sports tourism sector and its associated sports industries and sports initiatives.

4.Analysis of the Disadvantages of the Development

The degree of standardisation of service quality is insufficient. Currently, Sanya's sports tourism industry is facing many problems that are hindering its further development. In terms of the quality of sports tourism services, negative news is frequent, the service standard system for staff has not yet been clarified, supervision by the municipal disability department has weakened, and a perfect service standard system has not yet been established. There is a lack of depth in

product development. Today, many sports tourism projects focus too much on common water and beach sports. The products are highly similar in terms of both form and content, and innovation and differentiation are lacking. Take diving and surfing experience projects, for example. The services, pricing and activities provided by various businesses are almost identical, making it difficult to meet the growing need for diversification and personalisation among tourists. From January 2024, many Southeast Asian countries will introduce a visa-free policy for Chinese tourists. In order to compete with Southeast Asia's distinctive tourism resources and relatively cheaper prices, Sanya's service quality needs to be significantly improved.

In terms of facilities, Sanya's tourism infrastructure is generally well developed. However, for sports tourism, there is still a shortage of specialised facilities. Certain water sports bases are poorly equipped and lack specialised training and competition venues. Moreover, the equipment is not well maintained and public sports facilities are not evenly distributed. Some remote scenic spots have a lack of sports facilities. Sports tourism supporting services, such as changing rooms, shower rooms, resting places and so on, are not fully equipped in some places. This brings great inconvenience to tourists.

Talent shortage is also a thorny issue. Sports tourism, as a product of the integration of sports and tourism, urgently needs interdisciplinary talent who understand both the operation of sports projects and tourism service matters. However, the reserve of such talent in Sanya is currently extremely limited. Most interdisciplinary talent is concentrated in economically developed cities. The number of instructors for sports such as sailing and diving far fails to meet market demand, and some coaches urgently need to improve their professional standards. At the same time, the scarcity of talent in sports tourism planning and marketing has led to slow product research and development and poor market expansion results, failing to fully unleash the huge potential of the sports tourism market. Therefore, how to attract more professional talent to Hainan has become a critical issue.

Sports event brand building degree is low, although Sanya organized various types of events are international events, there is no lack of some international athletes. But in fact, in terms of level, visibility, scale and influence, these events still have a greater room for improvement. Such as the Tour of Hainan Island International Road Cycling Race, can refer to the Tour de France cycling race rules to enhance and improve, and will become a classic large-scale events in Hainan and the country. In addition to the unique events in Hainan publicity and promotion is weak. Like the 12th National Minority Traditional Sports Games held in November, many projects were fun but the marketing scope was limited to the province and did not form a wide range of dissemination. It is essential to identify marketable highlights from the event and carry out promotional campaigns before, during, and after the event to enhance its visibility.

Due to climatic conditions, Sanya tourism exists a clear distinction between off-peak seasons. Winter is the peak season for tourism, many tourists will flock to the sports tourism resources for a moment in short supply, which may lead to a decline in the quality of service. To the summer, stepping into the tourism off-season, the number of tourists suddenly dropped sharply. The sports tourism facilities and equipment have a lot of idleness, however, the operating cost has been high. The pressure on the enterprise's business has become even greater, which is important for the stable development of the sports tourism industry. But the marketing scope is limited to the province. This is very unfavorable to the stable development of the sports tourism industry.

In addition to fostering rich natural landscapes, Sanya's unique climate as a tropical coastal tourist destination also makes snakes, mosquitoes, and other animals active, which could endanger visitors'safety. A visitor to Sanya recently died after being bitten by an unidentified animal. Due to concerns about their personal safety, many tourists are reluctant to visit Sanya, which has a detrimental effect on the local tourism sector. Sanya should thus proactively take the necessary action. Stronger ecological management of important areas, frequent deworming and snake operations, the installation of important warning signs, and the marking of safe tour routes are all things that scenic area management should prioritize. Therefore, Sanya should actively take appropriate measures as soon as possible. Scenic area management departments should strengthen ecological governance in key areas, regularly carry out pest and snake control operations, set up prominent warning signs, and designate safe sightseeing routes. Relevant departments need to collaborate with scientific research institutions to study the distribution patterns and prevention-control

technologies of local dangerous organisms, develop suitable protective products, and promote their application. Tourism enterprises and tour guide teams should strengthen safety education for tourists, popularize preventive knowledge such as wearing protective gear and avoiding dangerous areas, as well as emergency treatment measures for wounds through multiple forms. Medical institutions should improve the stockpile of first-aid medicines such as anti-snake venom serums, and establish a rapid-response medical rescue mechanism, so as to enhance the safety of the tourism environment through systematic initiatives and to rebuild the trust of tourists in Sanya.

5.Analysis of Opportunities for the Development

As the social economy continues to grow steadily, people's quality of life keeps getting better. Health consciousness is also gradually increasing. The demand for tourism is shifting from traditional sightseeing tours to leisure activities, health and wellness initiatives, and sports tourism to fitness and sports. When tourism and leisure are skillfully combined, they completely align with this new consumer trend and offer enormous market potential. More and more travelers are now prepared to pay to These days, more and more travelers are prepared to shell out cash to take part in sports tourism initiatives, and they choose to seek out individualized, superior sports tourism experiences, which surely creates a huge market for Sanya sports tourism's success.

Sanya has a unique advantage in holding international sports events, and in the future, it may host more international first-class sports events such as large-scale comprehensive sports events or professional sports championships. Holding such high-profile events can significantly strengthen Sanya's international popularity and influence, attracting the world's attention to the city, and bringing in many international tourists, effectively promoting the internationalization of sports tourism, and moreover. Moreover, Sanya can learn from and emulate the more advanced international sports tourism development experience and business model by participating in the preparation and holding of the tournament, so as to better optimize its own industrial development standards.

In terms of policies, in accordance with documents such as the "Detailed Rules for the Implementation of Incentives for Influential Sports Events in Sanya" and the "Detailed Rules for the Implementation of Special Incentives for Large-Scale Concerts, Music Festivals, and High-Quality Theatrical Performances in Sanya", different reward schemes and standards apply to sports events held in Sanya based on actual metrics such as the number of participants and spectators. Varying incentive amounts are set to encourage and guide more market entities to host influential national and international sports events, attract more tourist flow, stimulate sports tourism consumption in Sanya, and promote the integrated development of sports with tourism and culture.

Sports star fever remains high. Since the successful conclusion of the Winter Olympics and the Paris Olympics and other large-scale sports events, the enthusiasm of global sports fans has not dissipated with the end of the events, but has continued to rise due to a series of shining up-and-coming sports stars such as Quan Hongchan and Sun Yingsha. Under their leadership, people are no longer satisfied with just watching the games through TV screens, but are eager to experience them in person, injecting a strong impetus to the development of sports tourism and making sports and tourism deeply integrated.

6.Analysis of Threats to the Development

Hainan Province is prone to frequent natural disasters. In the first half of 2024, Hainan experienced four heavy fogs, five widespread high-temperature periods, a round of low-temperature rainy weather, one tropical cyclone, five regional rainstorm processes, as well as multiple severe convective weather events and periodic meteorological droughts. In the second half of 2024, risks of meteorological disasters, floods and droughts, marine disasters, and geological hazards will all pose significant impacts on Hainan Island. For example, when Typhoon (Mojie) struck in 2024, it caused class suspensions and school closures for Hainan residents, while heavy rainfall inflicted substantial losses on industries including tourism. Outdoor sports tourism activities such as surfing, beach volleyball, and sailing were forced to be canceled or postponed, disrupting tourists' itineraries and experiences. Meanwhile, to ensure tourist safety, some scenic spots in Sanya were closed during typhoons. Severe typhoons even caused feelings of panic and anxiety among tourists, with such psychological impacts potentially persisting and affecting tourists' overall impression and satisfaction with Sanya's sports tourism. Therefore, tourism practitioners and the government in Sanya should reflect on how to enhance resilience against various

natural disasters, ensuring tourists can enjoy their visits with peace of mind and a strong sense of security.

The competition in the sports tourism market is fierce. Many domestic cities have begun to focus on the sports tourism industry and started planning its development, leading to increasingly intense competition. Qingdao, with its excellent harbor conditions, has a unique edge in developing water sports projects such as sailing and windsurfing; Xiamen has created highly personalized water sports tourism products relying on its beautiful coastal scenery and complete tourism facilities, thus attracting a large number of tourists. Internationally, Southeast Asian regions, due to their tropical climate, pleasant weather, charming beaches, and diverse marine ecosystems, as well as countries along the Mediterranean coast with profound historical and cultural heritage and high-quality coastal resources, have achieved mature development in sports tourism, continuously attracting tourists from around the world. Their annual tourist reception numbers have grown consecutively, making them global hotspots for sports tourism. In January 2024, Southeast Asian countries such as Singapore, Malaysia, and Thailand successively implemented visa-free policies for Chinese tourists, which have greatly facilitated outbound travel for Chinese visitors. In the first half of 2024, the number of Chinese outbound tourists reached 60.71 million, a year-on-year increase of 50.4%. Compared with Sanya, Southeast Asian countries like Thailand and Malaysia also possess abundant sports tourism resources, such as surfing, diving, golf, and beach sports. In terms of pricing, Thailand's overall consumption is relatively low; in terms of product variety, Thailand offers richer options like raw pickled dishes and fruits; in terms of service quality, Thailand is known as the "Land of Smiles"; and in terms of cultural characteristics, its ethnic customs are more prominent, with distinct exotic charm reflected in everything from clothing to language. Although outbound travel to Southeast Asia has various advantages, security issues are a major concern, posing a significant challenge in ensuring tourists' personal safety abroad. In short, Sanya should learn from others'strengths to make up for its own weaknesses, strive to improve service quality, enrich product diversity, and build a favorable environment to stand out in the market.

In such an environment, Sanya must enhance its own competitiveness, explore and highlight the unique features. Sanya is in the tropical maritime climate zone, climatic conditions to the sports tourism to bring some convenience, but natural disasters also lurks threat, typhoons, rainstorms, tsunamis and other natural disasters are frequent. Once it occurs, the facilities and equipment of the sports tourism facilities will be seriously damaged, the event is forced to be postponed or canceled, a variety of sports tourism programs can not be carried out normally, and the life of tourists can not be destroyed, and the tourists will not be able to enjoy the sports tourism. In addition, the safety of tourists will be threatened. Once a safety accident occurs, the number of tourists will fall dramatically, which will bring serious economic losses to the sports tourism industry, and marine pollution, beach erosion and other ecological problems should not be taken lightly, which will make the quality of sports tourism resources deteriorate, and tourists will play the experience will deteriorate, which will have a negative impact on the sustainable development of Sanya's sports tourism industry.

7.Development Suggestions on Sanya sports tourism

Create ethnic characteristics of sports tourism brand. Sanya is inhabited by the Li and Miao minorities, and has a wealth of minority cultural activities, such as bamboo pole dance, climbing coconut trees and so on. These traditional activities of ethnic minorities can be integrated with modern sports events to create a unique sports tourism brand in Sanya, so that tourists can feel the cultural charm of local ethnic minorities while participating in sports events. At the same time, it is also possible to develop sports activities such as tropical rainforest hiking with ethnic minority gathering places as tourist destinations, to enhance the fun and excitement of cultural activities, and to improve consumers' willingness to revisit.

Develop special theme programs. To promote Sanya sports tourism development theme characteristics of the project, it is necessary to integrate the local advantageous resources, from many aspects of innovation attempts, in-depth excavation of marine culture, shaping the marine adventure theme project. With Sanya's long coastline and the rich marine ecology, the launch of the deep-sea diving mystery tour can be developed. They can also explore mysterious underwater shipwreck relics and personally experience the wonders of the ocean. Additionally, round-the-world sailing experience activities can be carried out, where tourists sail through wind and waves in a sailboat, learn navigation knowledge and skills

during the voyage, appreciate the vastness and freedom of the ocean, and cultivate the courage to explore. It also develops rainforest traversing hiking routes, setting up several science stations along the way, with professional guides explaining rare plants and unique ecosystems for tourists, so that tourists can increase their knowledge in the process of getting close to nature. By hosting rainforest camping music festivals, camping bases are set up deep in the rainforest, where tourists fall asleep to the chirping of insects and birds at night, admire the rainforest scenery during the day, enjoy folk music performances at the festival, taste specialty cuisine, and indulge in a feast that blends nature and art.

Develop a healing product matrix. To promote the development of a healing product matrix for sports tourism in Sanya, it is necessary to fully leverage local advantageous resources and coordinate efforts in project planning, product integration, facility construction, promotion, talent cultivation, and other aspects. Utilize the vast beaches to carry out beach meditation and beach yoga classes, allowing tourists to walk barefoot on fine sand and relax to the sound of waves, alleviating stress; rely on the clear and blue seawater to launch relaxing programs such as paddleboarding tours and snorkeling adventures, where tourists can forget many troubles and gain inner peace while getting close to the ocean. For tourists seeking a deeper healing experience, multi-day forest wellness hiking activities can be organized, walking along lush tropical rainforests, breathing fresh air rich in negative oxygen ions, listening to birds singing, and letting the body absorb the power of nature.

In terms of healing, develop healing packages by inviting healing therapists to create tailor-made healing plans for tourists, combining Sanya's outdoor activities such as cycling and jogging with wellness services like hot spring therapy and traditional Chinese medical massage to help tourists restore physical functions and alleviate chronic illnesses. In terms of cultural integration, incorporate Hainan's local Li and Miao cultures by offering experiences of traditional Li and Miao sports such as bamboo pole jumping and stick pushing, allowing tourists to enjoy both the charm of ethnic culture and achieve physical and mental well-being. Additionally, organize traditional folk culture lectures and handicraft activities such as Li brocade weaving and Miao silver forging, enabling tourists to soothe their emotions and enrich their spiritual world through hands-on creation.

Build comfortable meditation cabins and yoga practice platforms by the seaside and in forests to create a serene and comfortable healing environment for tourists. Additionally, establish comprehensive wellness centers equipped with professional medical testing equipment such as physical fitness analyzers and mental health assessment systems, and formulate tailored healing plans based on visitors' physical and mental conditions. Various rehabilitation therapy rooms and relaxation massage rooms can also provide high-quality services to meet all kinds of wellness needs of tourists.

With the help of online social media platforms and travel websites, publish nice pictures and videos to show the unique charm of Sanya's sports tourism and healing commodities, and tell the stories of tourists' healing experiences, so as to attract customers who are willing to buy them. And reach a cooperative relationship with travel agencies and recreational organizations to create healing travel routes and packages according to the different customer groups, such as white-collar workers, the elderly, the healing crowd and so on, to develop targeted programs. We will launch targeted sales according to different customer groups, such as urban white-collar workers, the elderly, the healed, etc. We will attend domestic and international tourism exhibitions and summits of the recreation industry, and set up eye-catching booths to display and feel the healing products on the spot, so as to strengthen the fame and influence of the brand.

Cultivate a group of professional service personnel with knowledge of sports tourism, recreation and culture, invite experts in sports, recreation and culture to give comprehensive training to the practitioners, including sports rehabilitation guidance, psychological counseling, cultural explanations and other skills training, to improve the service standard, and encourage practitioners to participate in relevant academic exchanges and training activities at home and abroad, and continue to update their knowledge and concepts, so as to give tourists a more professional and attentive service, and to strengthen the brand name and influence. Provide tourists with more professional and attentive services, and promote the long-term development of Sanya's sports tourism and healing product matrix.

Build a dual platform for sports and socialization. To promote Sanya sports tourism to build sports and social platforms, in-depth changes and updates from many aspects, in terms of project planning, to develop a large number of both sports and social attributes of

the characteristics of the project, on the one hand, we must carefully arrange for teamwork sports, such as beach volleyball leagues, such as the form of team enrollment, so that tourists from different parts of the group to compete and deepen their understanding of each other while playing, on the other hand, also according to the different interests of the crowd to launch exclusive projects. On the other hand, it is also necessary to introduce exclusive programs according to different interest groups, set up parent-child yoga beach party for parent-child families, arrange parent-child interactive yoga movements and fun games to enhance the relationship between family members, but also to create communication opportunities between families.

Sports tourism venues should focus on adding social and exhibition function areas, forming an open leisure plaza by the beach, setting up enough leisure tables and chairs and sun-shading facilities, so that tourists can enjoy a comfortable rest time after sports, and naturally start communication, create a special sports performance exhibition hall, with physical objects, multimedia broadcasting and other means, to show the tourists in a variety of sports tourism projects in the excellent performance and results The creation of a specialized sports exhibition hall with physical objects, multimedia playback and other means to show the outstanding performance and achievements of tourists in various sports tourism programs, which meets the self-expression needs of tourists and can also stimulate the enthusiasm of other tourists.

Make full use of the popular social media platforms to share the sports and social journey in Sanya through live broadcasts, short videos, etc., showing the fun of sports and the charm of socializing, thus attracting fans to pay attention to and imitate them. Moreover, carrying out a variety of interactive topics and challenge activities on the social platforms prompts the tourists to share their own moments of sports, social stories, and special experiences during the sports tourism in Sanya, and rewarding those wonderful sharing. Those wonderful sharing will be given rewards, such as free experience programs, special souvenirs and other things, which can create a better word-of-mouth circulation effect.

Hire comprehensive talents with rich experience in organizing sports events, professional knowledge in tourism service, and the ability to plan social activities to plan and carry out sports and social activities to ensure that the activities are interesting and orderly, and provide comprehensive and systematic training to the existing sports tourism practitioners to improve their service awareness and level of social guidance, so that when tourists take part in the project, they can take the initiative to promote the exchange of communication between tourists, and create a warm and friendly social atmosphere. Form a warm and friendly social atmosphere, giving tourists a better, personalized service experience.

Multi-channel publicity and promotion. Strengthen online new media publicity, such as publicizing on platforms like Xiaohongshu, Jieyin, Ctrip, etc., signing up famous public figures to publicize Sanya's sports events, shooting promotional videos that keep up with current events, and enhancing the creativity of the advertisements; laying out more promotional advertisements offline, such as bus bodies, street lamps, and press conferences, to enhance the degree of exposure, and vigorously publicize Sanya's sports tourism through multi-channels.

Develop customized sports tourism products. Develop diversified customized sports tourism products tailored to the needs and interests of different tourist groups. For instance, for family travel, design parent-child outdoor adventure projects, beach sports meets, and other activities; for young tourists, launch more stimulating sports activities such as surfing, diving, and beach volleyball; for tourists seeking cultural experiences, prioritize the promotion of sports tourism routes integrated with ethnic minority cultures. By providing personalized and differentiated services, these efforts aim to meet the needs of different tourists and enhance their satisfaction with the travel experience.

Enhance the participation of local residents. The participation of local residents can significantly enhance the quality of tourists'experience and the authenticity of local ethnic characteristic tourism. Therefore, the local government and relevant policies should encourage local residents, especially ethnic minority groups, to actively engage in the development and operation of Sanya's sports tourism industry. This not only provides tourists with more authentic and ethnic-specific tourism cultural experiences but also promotes local economic development, increases residents' income, and enhances locals' perceived happiness, thereby fostering harmonious coexistence between tourists and local residents and driving the sustainable development of the local tourism industry. For example, ethnic minority residents can be invited to serve as coaches for projects like bamboo pole dancing, allowing tourists to experience the simplicity

and charm of ethnic customs through interaction. At the same time, it is essential to focus on protecting the local ecological environment and cultural heritage, ensuring that the development of sports tourism coexists harmoniously with the local society and environment, and upholding the core philosophy that lucid waters and lush mountains are invaluable assets.

Implement price tiering and optimize transportation. Strengthen the transportation connections between transportation hubs such as Sanya Phoenix International Airport and railway stations and sports tourism attractions. This can be achieved by adding more direct bus routes and increasing the number of shuttle buses to the attractions—for example, setting up dedicated waiting areas for sports tourism attraction shuttle routes at airports and railway stations, standardizing route signage to help tourists quickly locate boarding points. Meanwhile, improve bus route configurations to reduce transfer times and ensure tourists can reach attractions quickly. Additionally, appropriately deploy car rental service outlets at airports and railway stations, streamline the car rental process, and offer convenient services such as online booking with offline pickup, integrating car rental services seamlessly with public transportation to meet the travel needs of all types of tourists.

To achieve price differentiation between low and high seasons, enterprises should flexibly adjust pricing strategies according to the distinct characteristics of Sanya's tourism seasons. During the low season, when tourist numbers decline, significantly reduce prices for various sports tourism projects and launch comprehensive discount packages covering accommodation, catering, and sports activities—such as the "Low-Season Diving Vacation Package", which bundles diving courses with seaside resort hotel stays and specialty seafood dining—leveraging price advantages to compensate for the shortfall in visitor numbers. In the high season, moderately increase prices within a reasonable range while enhancing service offerings, such as setting up express lanes, exclusive rest areas, and other value-added services, to balance supply and demand and ensure corporate revenue. Additionally, implement time-of-day pricing by offering lower prices for marine sports in the morning to attract early-rising tourists, and slightly higher prices for evening beach activities paired with romantic seaside sunset ambiance and special musical performances.

8.Conclusion

Against the backdrop of "Event+Travel", sports tourism in Sanya has ushered in new development opportunities. While multiple large-scale sports events have been successfully held in Sanya, issues such as insufficient standardization of sports tourism service quality have consequently been exposed. Therefore, Sanya can strive to explore local characteristics, create ethnic-themed sports tourism brands, encourage local participation in the development and management of the tourism industry, continuously strengthen promotion and channel marketing, and promote the implementation of measures such as integrated development of sports tourism with other industries. These efforts will further enhance the development level and quality of sports tourism, provide tourists with more high-quality and diversified travel experiences and services, and inject new momentum and vitality into Sanya's economic and social development.

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Globalization and Chinese immigrants to Eastern Europe:Focusing on Russia

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Abstract: Globalization is a term loaded with political, economic, and cultural implications. The benefits of globalization are typically said to include the increased availability of affordable products, the possibility of instantaneous communication, and the development of infrastructure in previously isolated regions. The drawbacks of globalization typically include the negative impact associated with it on a society's traditional way of life and the damage done to the physical environment as a result of rapidly developed infrastructures. How globalization appears to the people living in transitional economies and to transnational migrants is little understood in a world in which the process of globalization is often seen through a Western lens and is presupposed to be a homogenizing (i.e., "westernizing") force. Nevertheless, globalization has concurrent narratives, one of which, explored in this book, is the growing role of China in the process of globalization and, indeed, the influence of China on the world. The impact of globalization on Chinese migration to Eastern Europe is unique as it has a particular policy interest because in the past decade it has proven to be predictive of trends in Europe as a whole. Anew flow of entrepreneurial migrants, who often had no connection to the historical, rural-based chains of migration that produced the earlier Chinese migrant populations of Eastern Europe, found it possible and profitable to do business and settle on the European periphery during a brief period of liberal migration controls. Erratic crackdowns on illegal migration in the absence of thought-through migration regimes resulted in a volatile situation, periodically generating migration flows from one country in the region to another. These were facilitated by, and gave further rise to, networks of kinship and information spanning both eastern and Western Europe. While this paper focuses on East Europe and Russia, it also attempts to review information on other eastern European countries (particularly Russia, Romania, Yugoslavia, and the Czech Republic) where it is available. In doing so, it intends to fill a gap in information on Chinese in Eastern Europe until more substantial research is produced, as well as to highlight the common features of, and links between, Chinese migration into individual eastern European countries as well as into some states there, especially Russian.

Keywords: Globalization, Chinese migrants, Eastern Europe, Sino-Soviet relations, shuttle trade, the surge of migration, immigration policies, migration flows, moved on legally, migration routes, residence permits, legally and illegally migration, irregular migrants, Integration and transnationalism

1. Introduction

The researcher will ask some ambitious questions in her work as an effort to characterize the globalization narrative that is "the rise of China". In particular, the volume attempts to understand whether increased Chinese migration since the inception of the reform era is an indicator of China's emergence as a global power. Additionally, the volume offers insights into the relationship between Chinese migrants and host societies, especially regarding the calibration needed among the latter due to changing economic realities.

The distinctiveness of Chinese migration to Eastern Europe and Russia is revealed throughout the book. In Eastern Europe, Chinese migrants tend to be small traders in cheap manufactured goods; in Central Asia, many Chinese are workers or managers on state projects, while in Russia, the tendency appears to be a combination of the previous two. (The writers do not include the Turkic Uyghur from

the northwest of China in their analysis of "Chinese" migrants to Eastern Europe and Russia) Despite this omission, the contributors agree that the outward movement of Chinese to Russia, Central Asia, and Eastern Europe is underpinned by China's economic success. As a result of China's economic strength, its influence with respect to globalization is distinct. "Globalization with Chinese characteristics... occurs through the penetration of Chinese products, investments and most prevalently, people throughout the world" (Tinguy. 1998).

Russia and some Eastern European countries experienced immigration from China until the 1920s, when the Soviet Union sealed its borders. Migration did not start to increase again until the "normalization" of Sino-Soviet relations under Gorbachev, which closely followed the liberalization of the PRC's rules governing travel abroad, made it possible for Chinese citizens to engage in trade across the Soviet border. Starting in 1987, northern Chinese began to take advantage of the simplified procedure to obtain private passports to engage in "shuttle trade" between China and the Soviet Far East and Siberia. Many of the first shuttle traders were moonlighting Chinese contract laborers, increasing numbers of whom had been invited to Russia on contracts during the same period. After the collapse of the Soviet Union and especially after the signing of a "Sino-Russian treaty" in 1992 waiving the visa requirement for overland group tourism in the bordering provinces, crossing the border became even easier. Russian news agencies in the era of globalization reported 1 million border crossings by Chinese citizens into the Russian Far East in 1992, rising to 2.5 million in 1993, according to one source. Another source concurs that 1993 was the peak year for the Chinese inflow, but cites a lower figure of 800,000 arrivals, noting that 900,000 Russians went to China in that year (Bagrov. 1999).

2. Research Problem and Questions

In the past few decades, China has undergone enormous political, economic, and demographic changes that have transformed the realities of migration to and from the country in the era of globalization. In addition to large flows of emigrants leaving in search of opportunities elsewhere and the persisting, more traditional streams of internal migrants for which China is known, a new trend of immigration to the fast- developing country is emerging. One aspect of Chinese migration that has captured considerable attention has been the number of Chinese entering countries illegally as so-called "irregular migrants".

On the other hand, as a result of these mentioned issues, Chinese immigrants, especially in Eastern Europe – as our study focus – start to have serious problems related to integration and influence the labor force in the countries in Eastern Europe that they have already immigrated to in the globalization era, as the rising of China as a "big market" in the international markets.

The paper seeks to answer the following questions:

1- What is the nature of China's immigrations past and present?

2- What are the main flows of Chinese Migration to Russia and Eastern Europe in the era of globalization?

3- What is the Chinese Transitioning into a Period of"New" Migration and globalization?

4- What is the nature of Chinese Migration Today in Eastern Europe?

5- What is the meaning of Chinese "Irregular Migration" to Eastern Europe?

6- Is there any other Chinese new "Migration Transition" to Eastern Europe?

7- What is the impact of Globalization on the raising of Chinese migration to Russia and Eastern Europe?

8- What is the influence of Globalization on the integration of Chinese immigrants in Eastern Europe societies?

9- What are the future aspects of the Chinese immigrants' integration into their immigrated societies in Eastern Europe?

10- On the light of the above mentioned, the researcher will conclude: What are the Prospects and challenges of globalization on Chinese immigrants to East Europe and Russia?

3. The Main Historical Chinese Migration Flows

The migration out of China that was truncated from the late nineteenth century through to the 1930s, depending on the destination, laid the basis for the present patterns of population movement. These began from Hong Kong and Taiwan from the 1950s and continued with changed immigration laws in the main potential destination areas from the 1960s. Acceleration has occurred since the opening of China itself from 1979. It is, nevertheless, still difficult

to leave China (Sinn, Elizabeth, 1995). There is still no real freedom of movement despite the increased numbers of Chinese migrants. Many who cannot obtain a passport and an exit visa attempt to leave illegally; although this option is expensive and can be dangerous. The numbers going legally and illegally are small relative to the size of China's population. Those leaving are still primarily from the provinces of Southern China, although there are signs that the migration fields are being extended further north, often pioneered by students from the main university centers. Most of the China's population is as yet untouched by international migration, either directly or indirectly, although given the upsurge in domestic movements since the early 1980s this cannot be said about internal migration (Seagrave, Sterling. 1995). Though the consequences of migration are varied: whether rising aspirations brought about through the increasing numbers moving to towns and cities, even temporarily, will impel international moves; whether the student migrations that have led to settlement will later generate chain movements through family reunification; or whether the new sojourner migrations will give rise to more permanent settlement and later chain migration will all depend upon policies not only in destination societies, but primarily in the direction taken in post-Deng China (Pan, Lynn. 1990).

Such idle speculation on hypothetical future directions diverts attention from the essential fact that migration is not just about numbers, but about control over wealth and ideas. Although the numbers of migrants from China are relatively small compared with the great migrations out of Europe from a much smaller base population earlier this century, the composition of the migrant flows has been heavily biased towards the postgraduate-level student, the professionals and the wealthier groups. Many of these wealthier groups are from the peripheral areas of Hong Kong and Taiwan, but they often maintain close links with their home areas in China, commuting regularly to them, and they have business interests there and among the wider networks of the overseas Chinese. Many of the students are indeed from China and their return, if it occurs, like the return of previous generations of students, is likely to have a major impact on the home society (Miao, Jian Hua, 1994).

The above mentioned survey indicate to the facts of Chinese migrations encounter barriers of speech, habits and manners the world over, but in China these are heavily reinforced by the system of "hu kou", or household registration, which permits routine discrimination against migrants by bureaucrats as well as by urbanites (a term applied in this special report to city-dwellers who have no rural connections themselves, and nor do their parents). In a survey conducted by the Chinese Academy of Social Sciences, nearly one-third of respondents in Shanghai said they would not like to live next door to a migrant, against only one-tenth who said they would rather not live next to a poor person. In Changchun, a less outward-looking city in the north-east, nearly two-thirds said they did not want to live next to a migrant. Chinese urbanites seem as anxious as Europeans about migration from poor to rich places, even though in China, the migrants are fellow citizens (www.economist.com).

Migration from China demonstrates continuities in spatial pattern and in certain types of migrants such as the new sojourners, both rich and poor. There are nevertheless important differences from past patterns in terms of wider participation from regions of origin and in terms of a greater range of migrant types as highly educated men and women, as well as poorer people, participate in population flows integrating China more fully into the world system. Whatever the future direction of political and economic change in China, population migration in and out of China is going to be a profound force for change around the Pacific Rim, elsewhere in the world, and in China itself as we move into the twenty-first century (Zhang, Jixun. January 1995).

4. Globalization and the Rise of Chinese Migration to Russia and Eastern Europe

Much of the former Soviet bloc in the period of globalization has become a destination for new Chinese migrants. Throughout Russia, Eastern Europe and Central Asia, Chinese migrants are engaged in entrepreneurial activities, primarily as petty merchants of consumer goods in unsteady economies. This book situates these migrants within the broader context of Chinese globalization and China’s economic "rise". It traces the origins of Chinese migration into the region, as well as the conditions that have allowed migrants to thrive. Furthermore, it discusses the perception that Chinese globalization is purely economic and explores the relationship among petty merchants, laborers, and institutional investors. Finally, by examining the movement of China’s minorities into Central Asia, this book challenges the ethnic construct of new "Chinese" migration (Xiao, B. 2001).

Informal “shuttle trade” had been a feature of the economies of scarcity in Eastern Europe since at least the 1960s, but Chinese traders developed it to an unprecedented scale, stepping in to fill a market vacuum created by non-existent or broken-down retail networks of low-price clothing and shoes. Venturing farther and farther by train and spending more and more time at their destinations, they first reached European Russia and then Hungary, which in 1988 signed a treaty waiving the visa requirement for Chinese tourists. According to a Chinese source, nearly 10,000 Chinese traders were registered as Moscow residents in 1992 (Humphrey, C. 1999).

The researcher here looks at the two main factors contributing to the surge of Chinese migration to Eastern Europe in 1989, as:

First, the crackdown on the student democracy movement in "Tiananmen Square sent a wave of anxiety through the fledgling private sector. Entrepreneurs were eager to secure an escape path for their capital and families in case the Government reversed the economic reforms.

Second, the recession of the Chinese economy in the beginning period of the "globalization" between 1989 and 1991 affected private entrepreneurs, managers at state-owned companies (who could not sell their stock), and workers (whose wages were being held back) alike. In this situation, stories of the success of shuttle traders, able to sell anything in Eastern Europe and getting rich, combined with news of the visa-free treaty with Hungary, sent tens of thousands of people packing (Epstein, Gabby, 2010).

And the researcher here emphasis to the "influences of globalization" on the Chinese migrations to Eastern Europe and Russia by the growth of Chinese businesses, changes in business climate, and immigration policies modified migration flows and generated new ones within the region. After 1993, the number of Chinese entering Russia fell, affected by the violent stand-off between President Yeltsin and the Supreme Soviet in October 1993 (Bagrov, M.V. 1999). The total number of Chinese entering Russia in 1997 was 449,000, with 464,200 in 1998. In the first six months of 2000, however, it jumped to 1.5 million, perhaps in response to the recovery of the Russian economy (Migration News, 2000). Many Chinese migrations to Eastern Europe moved on from Moscow to look for better business opportunities and increased safety. The main destination was Hungary. Then, the crackdown on Chinese immigration by Hungarian authorities in 1992 and, subsequently, increasing competition, lower profits, and increasing overheads in market trading led Chinese in Hungary to move to other eastern European countries (Gall, C. 2000).

Now, in the period of "globalization", Chinese Migrants headed for East Europe appear to be less skilled than those going to Australasia and North America, with large numbers moving into low-order services, trading, and manufacturing jobs. Large numbers of Chinese are also moving to Russian, while smaller numbers are going to other destinations as widely dispersed as the islands of the Pacific and countries in Latin America (Benton, Gregor, 1998). In choosing their destinations, all these migrants appear to be influenced by the global distribution of the Chinese as established by previous migrations. The researcher explains both:

(1) The responses of host societies towards Chinese migrants, from the Russian Far East to the Balkans.

(2) The migrants' variable rates of progress in assimilating into their new communities in the globalization era. These are complex issues that are justly explored in some depth (Wallace, C. 2009).

The researcher here asserts that negative globalization perceptions of Chinese migrants in part stem from the veneer of illegality surrounding Chinese migration to these regions, mainly vis-à-vis the migrants' circumvention of immigration requirements or commercial tariffs.

Yelena a Russian researcher "Y. Sadovskaya" uses disparate sources to demonstrate how some Chinese traders living in Russia and some Eastern Europe countries have failed to legally register their enterprises with the state (Y. Sadovskaya. 2012).

5. The Factors of the Surge of Chinese Migration to Russia and Eastern Europe in the Globalization Era

Some Chinese migrants who had obtained "Hungarian" or "Czech" residence permits moved on legally (with tourist or visitor visas) to Western Europe to work in workshops or restaurants. Some of those who failed to get a visa moved on clandestinely. Some were motivated by a preference for low-risk wage labour compared to doing business; others moved because they had lost the money they invested in starting their businesses. The researcher will mention here the following aspects, as follows:

1) Chinese migration routes to Eastern Europe

Chinese immigrants to Eastern Europe characterize the globalization narrative that is "the rise of China". In particular, the volume attempts to understand whether increased Chinese migration since the inception of the reform era is an indicator of China's emergence as a global power. Additionally, many scholars offer insights into the relationship between Chinese migrants' flows and host societies, especially in the globalization era due to changing economic realities (Todorovic, A. 2000). The main flows to Eastern Europe seem to have been the following:

A) From the Russian Far East to European Russia:

Some migrants from north-east China moved on from the Far East of Russia to Moscow, both as traders and as students. In the questionnaire study conducted by "Vitkovskaya" and "Zayonchkovskaya", one-fifth to one-fourth of respondents had visited other cities of the Russian Far East or eastern Siberia, apart from the location where they were interviewed. Almost one-tenth had been to a western Siberian city, 3 per cent had been to the Urals region; 15 per cent had been to Moscow and 6 per cent to St. Petersburg (Vitkovskaya. 2013).

B) From Moscow to Hungary, Romania, and the Czech Republic:

Between 1991 and 1993, many Chinese moved on from Moscow to look for better business opportunities and safety. Many others decided to move because of their inability to repatriate profits. Many of the migrants from Fujian in Hungary, Romania, and Italy had followed this trajectory. Neither Romania nor the Czech Republic had imposed a visa requirement on holders of official PRC passports, which were relatively easy to obtain. (For example, the executive vice president of the Fujian native-place association in Romania went to Russia in 1993, then to the Czech Republic where he stayed for one year commuting between the Czech Republic and Hungary. Finally, he moved to Romania in 1994 (Moore, M. 2001).

C) From Hungary to the Czech Republic, Romania, Yugoslavia, Russia, and the rest of Eastern Europe: Beginning in 1992, Romania and Czechoslovakia (later the Czech Republic) were the most popular destinations to Chinese, but Chinese also went to Slovenia, Poland, Albania, Bulgaria, the Ukraine, Russia, Lithuania, and later, after the end of the Bosnian war, to Yugoslavia and Bosnia. The Hungarian Government had become increasingly intolerant of the Chinese immigrated there. But they are still facing problems in renewing their residence permit in Hungary (Jiang, Y. 1999).

D) From Hungary and the Czech Republic, Austria:

There are some examples of Chinese migration along this route. When the clash between "Yeltsin" and the "Duma" broke out, some Chinese moved from Moscow to Budapest and tried trading at the market, but when business was bad, they moved via the Czech Republic with the help of some people. (Li, M. 1995).

2) The legal and illegal Chinese migration to Eastern Europe

The enormous number of border crossings by Chinese into Russia is accounted for mainly by group tourism, which serves as a legal cover for shuttle trading. Of the 800,000 Chinese entrants in 1993 cited by Russian sources, 410,000 entered as tourists, 237,000 for official purposes, and 33,400 on official invitations (57,100 were transport workers) (Bagrov, M.V. 1999).

Local authorities believe that 70 per cent of Chinese tourists engage in trade, which is illegal; others are agricultural and construction workers who simply want to avoid paying for the visa. To prevent tourists from remaining in Russia illegally, regional authorities extensively apply expulsions and deportations; each year since 1994, between 2,000 and 7,000 Chinese have been expelled from the maritime region, of which more than 1,000 were deported each year (Gelbras, V. 1999).

In the maritime region, 40 per cent of Chinese entrants overstayed their visa entitlement in 1994; in 1997, this dropped to 20 per cent, and in 1998 to less than 1 per cent. The number of Chinese who received administrative punishment in the region (for violating the visa regime, trading without a permit, and so on) has remained above 8,000 each year since 1994 (Gelbras, V. 1999).

Several Chinese took advantage of the renewed possibility to study in Russia, Ukraine, and Belarus and, in the early 1990s, also in central and Eastern Europe. Only a small number of these students were exclusively focused on their studies, while others concurrently engaged in trading, abandoned school after the completion of the preparatory language course, or did not show up at the school at all and merely used the student visa as a means of entering the country. In Belarus, China was the top country of origin of new foreign students in 1996

(Zagorets. 1997). Indicators indicate that only about half of the Chinese students' study, while the rest only trade. About 10 per cent of those Chinese students get a degree. (Kamezhuk, A.V. 1998).

In the late 1990s, some Chinese students began applying to branches of American colleges set up in Eastern Europe that offered students that chance to spend the last year or two of their studies in the United States, at colleges such us "McDaniel College Budapest" (formerly Western Maryland College Budapest). However, most migration to Eastern Europe has taken the form of entrepreneurial migration in which migrants either travelled on passports that needed no visas (i.e. service passports, so-called "xiao gongwu huzhao", supposed to be issued to public employees abroad on official business, but unofficially quite easily available to those on private trips), or applied for business, work or, later, family visit visas. This legal migration also partially relied on migration brokers who arrange for the documents needed to get a passport in China and come to Hungary (invitation letter from a Chinese company or in a relative's name, company registration in the migrant's name, enrollment in a school, and so on). Some of them can then also help migrants cross clandestinely to Western Europe. This was a much higher risk activity requiring greater familiarity with the terrain as it involved getting in touch with local human smugglers or even recruiting them from among local drivers. (Nyíri, P. 1998).

Most Chinese migration brokers subsequently expanded their services to helping new migrants apply for residence permits. According to the Chinese in Budapest, before the beginning of the armed conflicts over the Yugoslav succession, the Yugoslav-Austrian and Yugoslav-Italian borders were frequently used for clandestine crossings, as was the Czech Slovak German border. After the eruption of the Yugoslav conflicts, the southern route went mainly through the Hungarian Austrian border (Li, M. 2001).

After the crackdown on Chinese immigration in Hungary in 1991 and 1992, snakeheads appeared to redirect their business via Prague (Nyíri, P. 1998). According to Interior Ministry data at Hungary, the number of deportations of Chinese citizens without valid residence documents soared from 44 in 1995 to 843 in 2000 and then dropped to 261 in 2001. Since 1998, when Hungary fully acceded to the Geneva Convention, some of the detained Chinese have applied for asylum. In 2000, there were 200 such applications, accounting for about 3 per cent of all asylum claims. This time, Yugoslavia served as the entry point from which Chinese migrants crossed the border to Hungary, as it was relatively easy to obtain a Yugoslav visa in Beijing. Since China was a political ally of the "Milosevic" regime and Yugoslavia had few other places from which to expect investors, Belgrade had little incentive to tighten its visa regime. This resulted, particularly in the period after the NATO bombing of the PRC's embassy in Belgrade that symbolically sealed the friendship between the two states, in first one and then two Yugoslav flights a week arriving full of Chinese passengers (Morrison, J. 2000).

According to the head of the Yugoslav statistics office, "Srdan Bogusavljevic", 50,000 Chinese arrived in Yugoslavia in 2000. In addition, Yugoslavia attracted several Chinese entrepreneurs from other eastern European countries (principally Hungary) in 1998 and 1999 when, after the end of armed conflicts, they expected a post-war business boom. The free movement between Yugoslavia and the Serb controlled part of Bosnia, on the one hand, and loose controls on the Bosnian Croatian border, plus the long and jagged Croatian and Montenegrin coastline, on the other, has resulted in brisk Chinese border traffic, reflected in a growing number of apprehensions (Radulovic, Z. 2000). In the summer of 2000, two Yugoslav soldiers were arrested in Montenegro trying to take 25 Chinese to the coast (Balmer, C. 2000).

6. Chinese Immigrants to Russia

China's presence can be felt all over Blagoveshchensk, a Russian city 5,600 kilometers east of Moscow, but only just across the Amur River from China. There are students learning Chinese, plenty of Chinese-manufactured clothes and electronics in the stores, and Chinese restaurants serving stir-fried potatoes chased down with vodka. Yet you won't find many Chinese people here. The following survey indicates to: How many years did some Chinese residents live in Russia?

"According to the above graph", most Chinese immigrants are relative newcomers to Russia. In the critical Far East region, only 23% have spent more than five years in the country.

Few Chinese have affluent lifestyles in Russia – the majority, 61%, view their material condition as "medium" or "satisfactory", 15% as "bad" or "very bad", and 21% are "good" or "very good" .

Most migrants come with the help of those

already based there, who give them a hands up. The Chinese communities in Russia are tightly-knight, insular and highly trust-based, albeit fragmented into regional and ethnic groupings. According to the poll, 4% say they are directors or owners of an enterprise, 15% work for a Chinese firm, 9% work for a Russian firm and 53% are "independent entrepreneurs" (Charles, Ganske. 2013).

They typically learn enough Russian to get by, but no more. Only 9% have a good knowledge of the language and another 5% can read; 33% can explain themselves and 43% are bad at the language. Another 6% are currently studying the language at an institute. Only 4% don't know any Russian. Life is adaptive rather than planned – only 15% acquaint themselves with Russian laws or regulations. This is presumably because doing so makes little difference, with 82% of Chinese experiencing police requisitions, 49% rackets and 45% bribery amongst tax and customs officials (Anatoly, Karlin. 2014).

When the Soviet Union collapsed and the border between Russia and China opened up, predictions were rife of a massive wave of Chinese heading north. And it seemed that was possible: there were numerous opportunities in that part of Russia, the easternmost part of Siberia known as the Russian Far East. There just weren't many Russians to take advantage of those opportunities (Kucera, Joshua. 2010).

This above figure indicated to the issue of Chinese migration to Russia and its political consequences starts with one main question: how many of them are there? All reputable estimates are in the range of 200,000 to 400,000, with 500.000 as the absolute maximum, most of them shuttle traders or seasonal laborers (Cui, Xiaohuo. 2008). According to the Federal Migration Service, in 2006 a total of 202,000 Chinese got registered as temporary workers in Russia, or 20% of all Gastarbeiters; although their numbers increased to 331,000 in 2007, they made up only 17% of all immigrant labor. Meanwhile, just across the river, China is bursting at the seams. The three provinces of North–Eastern China, which are: Heilongjiang, Jilin, and Liaoning have 110 million people between them (Federal Migration Service, 2006).

* The researcher here will indicate some facts regarding the Chinese immigrants to Russia, as follow:

1) It's impossible to know the exact level of Chinese migration into the Russian Far East; Russia has not run a census in over a decade. But by all indications, a significant river of people is surging across the border.

2) The "Moscow Carnegie Center", the only organization to launch an independent study, claimed that there were about 250,000 Chinese in Russia in 1997. The Interior Ministry has claimed that there are 2 million. Other estimates place the Chinese population at 5 million (International Organization for Migration "IOM". 2013).

3) Regardless, the Federal Migration Service fears a flood. The service has repeatedly warned that the Chinese could become the dominant ethnic group in the Russian Far East in 20 to 30 years. Such an occurrence would require an annual influx of about 250,000 to 300,000 Chinese, less than one-third the rate that currently claims.

4) The researcher believes that there are reasons to believe that the Chinese flow to Russia will hit these levels, with at least tacit help from Beijing. China has more than 1.2 billion people more than eight times Russia's population. China's Manchurian population has increased 13 percent in a little more than a decade (Zeihan, Peter. 2014).

5) Any kind of Chinese expansion into the region will eventually bring about a question: What is Beijing's claim there? Most of the border region - an area roughly the size of Iran - used to be Chinese. China and Russia signed a border agreement in 1999, but the Beijing government has never formally accepted the agreement (Repnikova, Maria. 2009).

6) The Russian Far East also holds resources that are valuable to an ever-growing China. The region is rich in natural resources such as oil, gas and timber. The size of the Russian work force is shrinking as the country grows older. China's young - and growing - population is more than able to fill the gap and exploit these resources (Nyíri, Pál. 2002).

7) Over time, Moscow will simply let the region slip from its grasp. The territory at stake includes all of Russia's access to the Pacific Ocean. Vladivostok is Russia's only warm-water Pacific port. Nikolayevsk, at the mouth of the Amur River, processes most of Siberia's remaining exports. Both are well within former Chinese territory (Minakir, Pavel A. 2012).

8) Police in Russian cities are responding with aggressive ethnic profiling. Law enforcement personnel check the documentation of foreigners, and they actively target ethnic Asians. The policy results from a widespread feeling that China is the source of undesirable immigration. (newsinfo.inquirer.net).

That's means that – according to the above facts mentioned – China migrations to Russia cause big challenges to the Russian government. Local Russian officials and media reports often say the region faces a looming threat from a Chinese population that outnumbers Russians along the Far East border. Russian officials and regional governors have long expressed fears that a population drain in the Far East following the collapse of the Soviet Union could see the region one day fall under Chinese control (newsinfo.inquirer.net).

7. Globalization and the Integration of Chinese Immigrants in Eastern European Societies

Chinese Migrants in Russia, Central Asia, and Eastern Europe explores the challenges Chinese migrants experience with respect to integration into host societies in the globalization. The researcher describes an "absence of attachment to their destinations", with many migrants often speaking very little of the local language. In addition, a common theme in all the papers is the Chinese migrants' fungible view of their host nations. Russia, Serbia, and Kazakhstan are not considered destinations in themselves but merely represent opportunities to engage in trade. In other locations, such as in the Russian Far East or Eastern Europe, migrants reported being simply end route to more "desirable" destinations. Larin states, "For all the products and labor they provide, if Chinese skirt local laws and continue to remain isolated from the larger community, then they will continue to be received with unease. The prospect of improved relations therefore depends on Chinese desires to assimilate and stay" (Larin. 2013).

However, while conceding, "much of the new Chinese Diaspora in Eastern Europe does not desire to integrate", Rucker-Chang details how an increasing desire among Chinese migrants to bring their children from their hometowns and send them to local schools is an indicator of longer-term settlement. Rucker-Chang concludes her absorbing assessment of Chinese representations in Serbian, Croatian, Bosnian, and Slovenian film saying, "The fact that these migrants are given treatment in cultural products presents an interesting case study of development of acceptance and identity in the Yugoslav successor states" (Rucker, Chang. 2014). The researcher here will indicate the main activities for the Chinese immigrants to Russia and Eastern Europe, as follow:

A) Economic activities

Most Chinese in Eastern Europe deal with the import, wholesale, or retail of low-price clothes and shoes from China. The Chinese took advantage of economies that were, to varying degrees, undersupplied, and filled a supply gap by offering cheap but popular clothes of the kind made in China for low-price Western retail chains. Contrary to traditional Chinese migrants to Western Europe, these migrants, thanks to their background, had the cultural capital, the mobility, and the means of communication necessary to develop close ties with state enterprises in China, which supplied them with merchandise at low subsidized prices and on favourable credit terms. (For the enterprises, this was a means of expanding into new markets and pulling down stocks). Overseas companies informally affiliated with businesses in China could serve as channels for reinvesting money transferred to them in China in the guise of joint ventures, securing not only more favourable tax treatment but also the possibility to "repatriate" profits, taking them out of China (Nyíri, Pál. 2002).

As most of the Chinese are self-employed, only a minority is employed by other, almost exclusively Chinese, enterprises. In Hungary, according to the International Labor Organization (ILO), 1,700 Chinese had work permits in 1999. According to the Russian Federal Migration Service, 24,256 Chinese held work permits in Russia in 1999, but most of these were employed in agriculture and construction in the Far Eastern and Siberian regions of the country (International Labor Organization "ILO". 2000).

B) Integration and transnationalism

Chinese migration, even illegal migration, is happening not just from East to West, but also in the opposite direction. Many Chinese, especially those from "Zhejiang" and "Fujian" Provinces, have family members working in garment or leather workshops in Italy or in restaurants in Spain, Germany, or England, most of whom made their way there from Hungary. Individual stories of Chinese in Eastern Europe reveal an extraordinary degree of mobility. In the process of my fieldwork in Hungary since 1992, you can meet people who started trading in Hungary, were unsuccessful or lost their money at the casino, and went to Italy or Germany to work in leather workshops or restaurants for three or five years. Now they consider investing the money earned in Hungary or Romania once again as they want to develop their own businesses.

Others, whose applications for political asylum in Germany had been turned down, chose to re-enter Hungary or Russia illegally because they thought it was easier to re-legalize their status there. Several more who started trading in Russia in the early 1990s went on to Hungary, but as residence permit policies were tightened in 1992, returned to Russia (Larin, A.G. 1998).

For such Chinese migrant families at Hungary, as the cash-generating destination in which Chinese can be bosses, albeit harassed by the authorities and the local people, is one of the nodes in a transnational migratory portfolio. Another node is the destination that offers them existential security, international mobility, and a good living environment for their later years, and their children access to education and to professional jobs (Blokhin. 2001).

8. Globalization and Immigration Policies of Eastern European and Russia to Chinese Immigration

Immigration policies of Eastern European countries show considerable variations. Russia created a Federal Migration Service soon after the collapse of the Soviet Union to cope primarily with ethnic Russian refugees and forced migrants from the other successor states, but also with huge numbers of other, particularly Afghan, refugees. A Federal Migration Program was enacted in 1992 and has been periodically reviewed (the latest version is for the period from 2010 to 2014) (Blokhin, 2001). Here, the researcher will indicate the impact of globalization on Chinese immigrants to Eastern Europe, as follow:

A- Globalization and the political practices towards Chinese migration to Russia and Eastern Europe

The reality of Chinese migration to Russia has been much more affected by federal and regional policies on entry, entrepreneurship, and labor than by federal migration policy. On the one hand, this is because Chinese in Russia are more interested in the security and returns of their economic activities, the ability to repatriate profits and to be free of official harassment, than in long-term efforts at integration.

In Gelbras' (1999) study, about one third of Chinese respondents in Moscow intend to return home, while another third say their decision will depend on how their business goes; only one-third would like to stay in Russia. While 35 per cent would like to expand their business in Russia, almost as many would like to open a business in China (Gelbras, V. 1999). Only 10 per cent would like their children to live in Russia, while 40 per cent do not, and 40 per cent "have not considered the question" (Gelbras, V. 1999).

As already stated above, most Chinese entering Russia took advantage of the visa waiver for border tourism to engage in trade. But, at the same time, some regional political leaders have emphasized the "demographic, economic, and ecological danger" posed by Chinese migrants who supposedly plunder Russia's natural resources, take profits out of the country, and gradually displace the local population (Larina, L. 1999).

The emphasis in immigration practices towards Chinese still varied considerably across the countries. Hungary, the country with the smallest relative and absolute numbers of immigrants among the three front- runners for accession, has gradually emerged as the country with the smallest immigrant population (144,000, or 1.5% of the population, in 1997 – of which most are ethnic Hungarians – and the most restrictive immigration practices. Thus, contrary to Poland and the Czech Republic where asylum seekers enjoy a certain degree of freedom of movement and, under certain conditions, the right to work, in Hungary they are detained in prison-like centers if they have no legal title to be present. Yet, in effect, Chinese have been treated with pointed discourtesy. Most Chinese in Hungary, as detailed above, enter with visitor, employee, or entrepreneurial visas, with which they can apply for temporary residence permits valid for one or two years. Getting a visa to Hungary is much more difficult than to Russia and, beginning in 1992, it has progressively moved toward even tighter restrictions. Foreign residents do not have the automatic right to bring dependents, even minor children, to Hungary. My Chinese informants maintain that (Mao, C. 2000).

Neither central nor local governments in Eastern Europe have formulated a reception policy or undertaken any efforts to integrate Chinese migrants, seeing them purely in terms of a case of policing. Both in Budapest (1995) and Moscow (1999), city governments supported surveys of the Chinese populations, but then did nothing with the resulting findings (Maslov, A. 2003).

B- Globalization and the correlation between Chinese migration and Chinese government influence in Russia and Eastern Europe

The correlation between Chinese migration

and Chinese government influence in Russia, Central Asia, and Eastern Europe is explored, but some areas of research remain unexplored. Importantly, some researchers describe how in the view of the Chinese state, “Chinese migration has even evolved from, treacherous to tolerate but ideologically suspect to patriotic", as can be seen through the pro-PRC bent of voluntary overseas Chinese associations” .

Some other researchers explain, “Notwithstanding their informality, the Han Chinese often seeks or receives protection from local Chinese embassies” . This is where an examination of ethnic minority migration from China would have provided a richer analysis. In general, foreign connections among the "Uyghur", for example, are still viewed suspiciously, especially in Central Asia, as China often cites security concerns posed by the "Uyghur". Chinese migration often precedes or is concurrent with greater Chinese state approaches to other nations. The Chinese government's involvement in large-scale natural resource projects in Central Asia is one such case. Originating from the necessity to secure oil and gas to fuel economic growth in eastern China, as well as being a strategic gambit, the Chinese government's increased engagement with Central Asia has been significant. Despite unease among the local population about China's intentions and disputes over commercial information sharing between joint ventures, China has managed to impose its agenda among Central Asian governments on rooting out Uyghur activism in Central Asia. Given this influence, the analyses on Central Asia would have benefited from more discussion on the Shanghai Cooperation Organization (SCO), which is an emerging model for an association of nations independent of “western” power (Henryk Szadziewski. 2014).

Conversely, the researcher thinks here about: how the volatile economies and corruption – in globalization era– in many of the host nations under review in essence present opportunities for Chinese migrant traders, forming a significant migratory pull factor a force that induces individuals to select a particular migratory destination. In some countries, such as Serbia, rather than competing with local businesses, Chinese migrants have been instrumental in supplying consumers with everyday items when the domestic economy could not otherwise provide them due to political instability. Writing about Russia, Flex, explains that corrupt societies require a sort of “criminal adaptation” on the part of the migrants, which they justify as a “[response] to a broken system within which their rights are violated” (Felix, B. 2013).

While lack of transparency in host nations necessitates Chinese traders operate in the shadow economy, the authors argue that the more rooted Chinese migrants become in their new surroundings, the more migrants view corruption as a problem. Larin writes that corruption is the greatest source of unhappiness among Chinese in the Russian Far East, even more upsetting than xenophobia. Interestingly, the domestic political environment in Russia is most likely responsible for anti-Chinese sentiments, according to Larin. Politicians aspiring to western ideals of democracy, as well as nationalists, are culpable due to their fears over China's rise “as a counterweight to the West” (Larin. 2013). Some other research also propose it is the small numbers of Chinese that add to anti- Chinese feeling. In surveys conducted in the Russian Far East, he found “the smaller the number of Chinese, the more intense the fears and phobias” (Felix, B. 2013).

The researcher here concludes that perhaps the most intriguing quirk of history concerning Chinese migration and subsequent xenophobia is the case of Serbia. A rumor has persisted in the country that Chinese were brought in by "Slobodan Milosevic" to influence elections in his favor in exchange for citizenship. Despite the small number of Chinese in "Serbia" small enough that they would not have been able to influence any election the migrants' presence has been tarnished with the discredited Milosevic. And that's an evident that Chinese Migrants in Russia, Central Asia and Eastern Europe explore the challenges Chinese migrants experience with respect to integration into host societies in the era of globalization.

9. Conclusion: The Prospects and Challenges of Globalization on Chinese Immigrants to East Europe and Russia

Chinese migration to Eastern Europe has a particular policy interest in that it has in the past decade until the era of globalization, as it proven to be predictive of trends in Russia and Eastern Europe as a whole. Anew flow of entrepreneurial Chinese migrants, who often had no connection to the historical, rural- based chains of migration that produced the earlier Chinese migrant populations of Eastern Europe, has found it possible and profitable to do business and settle on the European

periphery during a brief period of liberal migration controls. Erratic crackdowns on illegal migration in the absence of thought-through migration regimes resulted in a volatile situation, periodically generating migration flows from one country in the region to another. These were facilitated by, and gave further rise to, networks of kinship and information spanning both eastern and Western Europe. Gradually, models of entrepreneurial activity initiated in Russia and Eastern Europe, namely the importing and distribution of Chinese-made clothing and other consumer goods, has been picked up by Chinese migrants to southern Europe and then in Eastern Europe, countries with more mature and regulated trade regimes and higher business costs.

The distinctiveness of Chinese migration to Russia, Central Asia, and Eastern Europe is revealed throughout this paper. In Eastern Europe, Chinese migrants tend to be small traders in cheap manufactured goods; in Central Asia, many Chinese are workers or managers on state projects, while in Russia, the tendency appears to be a combination of the previous two. The contributors agreed that the outward movement of Chinese to Russia, Central Asia, and Europe is underpinned by China's economic success. As a result of China's economic strength, its influence with respect to globalization is distinct. As Rucker-Chang explains, “Globalization with Chinese characteristics… occurs through the penetration of Chinese products, investments and most prevalently, people throughout the world” .

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Empowering Regional Economies through Rural Brand Strategy in Scene Tourism: A Case Study of Danyang Erhu Town

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Abstract: With the wave of social development, the problem of rural development is not being timely and deviating from urban development is inevitable in the Jiangnan region. This article summarizes and showcases the unique products and abundant resources of the Danyang region through a study of its development history, highlighting the "Danyang Erhu" brand. On this basis, research the development process and current situation ofthe erhu brand, find out the dilemma of brand development, give a strategic plan based on the existing brand in combination with the scenario theory, and form an exclusive development vision of "One Line the Belt and Road One Cluster". And analyze and evaluate the impact of brand strategy planning, horizontally compare various rural economic development projects, and provide research for expanding the planning path and enhancing the driving force of rural economic development in the next step.

Keywords: Scene tourism, rural products, brand planning

Introduction

In the process of socio-economic development, the application scope of scenario theory continues to expand with changes in consumer groups and environments. From basic performing arts and other concrete concepts, it gradually evolved into a collection of abstract concepts, and its rich connotations, combined with the perspective of the integration of communication and tourism studies, constitute the emerging expression of scene tourism. Danyang is rich in natural resources but now faces pain points that urgently need to be addressed, such as scattered locations, weak promotion of characteristic resources, and low public awareness.

The scenario theory and scenario tourism theory provide a feasible construction path planning for Danyang's characteristic brands by constructing cultural facilities, consumer aggregates, and focusing on the construction of consumer psychological needs. The construction ideas provided in this article enable the organic integration of Danyang's characteristic brands with local development, abandoning the problem of blindly developing the economy in other individual rural areas, solving the reality of scattered cultural resources and low cohesion, and providing new ideas for the development of Danyang's rural economy.

1. Conceptual Explanation and Literature Review

1.1 Research on Scene Theory

Daniel Silver and Terry N. Clark proposed the "context theory" in the 1990s. They believe that a scene is not just a physical space, but a collection of overall cultural styles and aesthetic features (Searle, 2019). The combination of cultural facilities, activities, and residents in the region collectively constitutes the scene, providing residents with a culture, consumption, and lifestyle with regional characteristics. Cultural scenes not only create new patterns of association between residents and regions but also open new cultural support paths for innovative development in the region. Under the scenario theory, the design strategy of rural cultural tourism can be based on cultural heritage. Based on card planning, integrating the value cohesion created by cultural scenes, and promoting innovative development of regional economy. Scene theory is based on consumption, locking individual action goals in cultural and value demands, emphasizing cultural life in the environment.

The impact of the combination of entertainment facilities on the regional economy. Li et al. (2022) pointed out that scenario theory can play a positive role in promoting effective management and

revitalization of cultural heritage. Chen et al. (2022) constructed an analytical framework based on scenario theory and spatial production theory and found that the economic and social value expression of rural cultural tourism integration is more prominent, while there is still room for improvement in cultural value expression. Wu et al. (2024) used CiteSpace software to quantitatively analyze the process of localization of scene theory in China, from the introduction of the theory to innovative development. They found that current papers and works related to scene theory are integrating with more themes and methods and show significant growth.

1.2 Research on Scene Tourism

Context tourism refers to a scenario-based tourism approach that creates cultural and entertainment spaces in tourist destinations, gathers regional characteristics, and creates ecological places with subjectivity, experientiality, and community characteristics. There is relatively little research on the concept definition and related studies of scenic tourism by domestic and foreign scholars. Although there are differences in the specific conceptual definitions, they all emphasize the importance of cultural experience. Yamamura (2015) defined scenario tourism as a form of tourism consumption that utilizes local related scenes (such as movies, TV shows, cultural works, etc.) to promote the development of tourism communities and related industries. Seaton et al. (2015) further defined scenario tourism based on this, stating that its travel behavior is fully or partially driven by creative elements such as narrative, characters, locations, and other forms of popular culture. With the development of China's cultural and tourism industry in recent years and the upgrading of consumer awareness, experiential culture has become a new business model that empowers new scenarios. Li et al. (2020) first proposed the concept of scenario tourism in China, pointing out that scenario tourism is a new form of tourism consumption that breaks the traditional characteristic of the objective existence of tourism consumption objects and highlights the creation of conceptual or fictional culture in tourism scenarios. Fan et al. (2021) proposed that scenario tourism can more specifically and microscopically express the characteristics of tourism in the era of mobile internet. They believe that scenario tourism theory includes location-based all-round services, services based on social personality credit index, and immersive experiences based on the body. Hou (2022) and Zhou (2023) respectively studied scenario tourism marketing strategies and spatial design using the Yangtze River Delta region and Yixing Yada Town as examples, demonstrating the feasibility of applying scenario theory to regional development. However, there is still a lack of research on the practical effects of constructing cultural scenes in rural areas, and further in-depth research is needed in conjunction with scene theory.

1.3 Related research on brand planning

Brand planning was originally an important area of enterprise management. Qin et al. (2006) first introduced brand concepts into ecotourism management, pointing out that brands need to have inherent implicit elements and external explicit elements, with characteristics such as recognition, value, and leadership. Planning is a pre-conception or decision made by the planning subject based on the brand's constituent elements. Xing et al. (2009) further clarified that the connotation of tourism brand planning is the overall comprehensive planning process of tourism products, tourism enterprises, and tourism destinations from the perspective of business strategy and brand concept. From the perspective of brand planning philosophy, China's tourism brand planning generally lacks theme culture and image design, and the planning content tends to be homogeneous. Therefore, domestic scholars have conducted more in-depth research on tourism brand planning. Qin (2013) pointed out that for urban planning to reflect the characteristics of the city at the level of strategic development, cultural features need to be incorporated into the urban strategic concept. Zhu et al. (2020) Based on the clustering entropy method, a study was conducted on the regional tourism brand planning in Shanxi Province. From the perspective of brand management, it was pointed out that the construction of tourism regional brands can achieve cross-regional integration and sharing of resources. Li (2022) proposed from the perspective of cultural perception that urban brand planning should pay attention to the individuality of urban culture and people's feelings. However, there are few existing studies that construct regional tourism brand strategic planning strategies from the perspective of scenario theory, and there is a lack of relevant research on how brand planning strategies empower regional economic development.

In the context of rural revitalization, the brand strategy planning of Zhao's erhu has endowed the

Danyang area with richer cultural scenes, effectively developing and protecting natural resources, while also providing impetus for high-quality development of rural economy. This article will conduct in-depth research on the development and current situation of rural products in Danyang, analyze the current situation and existing pain points of Danyang erhu intangible cultural heritage, construct user profiles and tourism space scenes, plan the brand development strategy of Danyang erhu town, expand the application of rural products in digital virtual scenes, and explore the path of Zhao's erhu brand empowering Danyang's economic development. To promote the coordinated development of industrial economy in Danyang area and provide solutions for the construction of cultural and tourism spaces in rural areas.

2. Development and Current Status of Rural Products in Danyang

2.1 Danyang location

Danyang is located in the Yangtze River Delta, the corridor of the Shanghai Economic Circle, in the south of Jiangsu Province, and the Taihu Lake basin. Its geographical location is superior, located on the south bank of the lower reaches of the Yangtze River, with the advantage of connecting the east and opening the west. Danyang is an important part of the water towns in Jiangnan. This place has a dense water network and fertile land and has been a land of fish and rice since ancient times. Having abundant natural resources and good ecological advantages. Danyang has a long history and has been one of the political, economic, and cultural centers ofthe Jiangnan region since ancient times.

2.2 Danyang resources

2.2.1 Abundant natural resources

Among the land area of Danyang City, plains account for 72%, and low mountains and hills account for 28%. This terrain distribution provides conditions for agricultural development and diversified management. The cultivated land covers an area of 56900 hectares, including 53800 hectares of farmland protection zone, which is conducive to the planting of food crops and ensuring food security.

Danyang City is rich in water resources, with 96 surface water channels and a total length of 464 kilometers, forming the main waterways such as the Beijing Hangzhou Grand Canal and the Jiuqu River water system network. In addition, there are 9 reservoirs of various sizes and nearly 10000 ponds, providing water for agricultural irrigation, aquaculture, and residential use. Adequate water sources. Meanwhile, the available transit water is mainly from the Yangtze River, which can divert approximately 500 million cubic meters of water annually.

2.2.2 Diverse folk cultures

2.2.2.1 Jizi Temple

The Jizi Temple, situated in Jiuli Town, Danyang, is an ancient temple with a history spanning over 2,000 years. It hosts temple fairs annually, attracting a large number of tourists and devotees to visit and worship. Additionally, the festive celebrations in the Danyang region are rich and colorful, such as dragon and lion dances during the Spring Festival, dragon boat races during the Dragon Boat Festival, and moon-viewing during the Mid-Autumn Festival, all reflecting the enthusiasm and joy of the local people.

2.2.2.2 The "Three Early" culture of Danyang

Lingkou Town is a part of the daily life of residents and an important way for them to socialize and relax. In the early morning tea house, the elderly gather and order a pot of fragrant morning tea, savoring the sweetness and bitterness of the tea leaves, as if savoring the ups and downs of life. After morning tea, it's morning noodles. The morning noodles in Lingkou Town are unique, with chewy texture, delicious broth, and abundant ingredients. Whether it's a simple noodle soup or a luxury version with various pieces of meat and vegetables, it's appetizing.

Early morning wine is another major feature of the "Three Early Days" culture. The early liquor in Lingkou Town is not strong liquor, but mainly locally brewed rice wine. This rice wine has a mellow taste and a low alcohol content, making it suitable for drinking in the morning. Morning wine not only warms the body but also refreshes the mind and injects vitality into the new day. Accompanied by morning wine, people taste the fine wine while communicating the bits and pieces of life. This cultural tradition has been passed down from generation to generation, becoming a unique cultural symbol of Lingkou Town and a major attraction for foreign tourists.

2.3 Danyang characteristic brand

During the Wanli period of the Ming Dynasty, Wang (1993) once pointed out that the people of Jiangnan were "both prosperous and wise, and when it comes to cultural relics such as crowns and covers, they are extremely skilled and have a salty and exquisite mind. Although the five merchants

gathered and the resources were abundant, they were not natural products. They were mostly made by human labor, which was enough to seize the power of nature. This indicates that the hundred skilled crafts in the Jiangnan region are outstanding, with exquisite craftsmanship in manufacturing. Indeed, the Jiangnan region is renowned as the hometown of numerous crafts, boasting a rich history of folk handicrafts, a diverse range of categories, and numerous masterpieces (Wang, 2024).

In the more than 2000 years of Danyang's history of building the city, there have been many products and resources with local characteristics, such as Danyang cuisine meat, jar sealing wine, barley Congee, Yanling duck dumplings, sweet and sour radish, Lingkou dried radish and other delicacies, as well as technical works such as Zhao's erhu and Zhang Forging, which have been passed down to the present day, and various cultural relics such as tomb stone carvings of the Southern Dynasty, Qi Liang culture, Jiuli scenery, Lian Lake, the former site of the Party branch and other cultural relics that complement each other, as well as Danyang glasses, which are the essence of modern entrepreneurship, can be said that Danyang is extremely rich in various products and resources. Among them, Danyang Zhao's erhu has become increasingly prominent in recent years, standing out among a group of characteristic products that have been passed down to this day.

The "Zhao Jun Qin Workshop" has trained two apprentices based on family inheritance and retained the essence of traditional handcrafting. Nowadays, over 1000 pieces of Zhao's erhu are produced annually.

With the emergence of traditional culture fever in recent years, ethnic instruments such as the erhu have been "heated up", and the erhu has gradually entered the vision of more people. Zhao Jun said, "Only innovation can develop and inherit it. With the inheritance of erhu skills, the craftsmanship spirit in the Jiangnan spirit has also been passed down. This article relies on the craftsmanship of erhu production and the inheritance of the Jiangnan craftsman spirit and aims to address the problems of excessive and blind commercial development and uncoordinated economic transformation in rural areas of Jiangnan, and to carry out brand strategy planning for the location of Danyang Zhao's erhu, empowering rural economic development.

3. The Current Status and Existing Pain Points of Danyang Erhu Intangible Cultural Heritage

3.1 Current Development and Shortcomings of Erhu Brands

Zhao Jun, the inheritor and artist of the "Danyang Zhao Erhu" brand, has been particularly active in the digital economy wave in recent years.

He is not only a guardian of traditional culture, but also a pioneer in innovative marketing strategies. Through carefully planned online live streaming activities, Zhao Jun cleverly combined erhu performance with product sales, opening a new business model. His live streaming room has become a platform where culture and business intersect, where audiences can enjoy exquisite erhu performances and purchase authentic Danyang Zhao's erhu products. This live streaming method, which combines traditional art and modern technology, greatly enhances the brand's visibility and influence, injects new vitality into it, and makes it shine with unique charm in the digital age.

In the current market environment, the development of the Danyang erhu brand is limited by individual abilities and resources. Brand building has not yet broken through existing limitations and has not successfully crossed specific social circles to promote itself to a broader market. This not only hinders the improvement of its brand awareness but also affects its driving effect on the local rural economy. Although Danyang has abundant natural resources, they are numerous and scattered, making it difficult to form clusters and bring economic benefits. To truly achieve brand influence expansion, it is necessary to break down these barriers, explore and unleash potential economic potential. This requires multi-party cooperation, from the government to enterprises and civil society organizations, to work together and stimulate new potential for the brand, making Danyang Erhu an important force in promoting local economic development.

This article constructs a cultural scene space by utilizing the cultural symbol of "Danyang Erhu" and constructs a talisman based on the original conditions. The path of revitalizing rural economic development with local characteristics. To avoid the current situation where some rural areas in Jiangnan are affected by foreign cultural values and changes in residents' lifestyles due to their high degree of internationalization, resulting in cultural landscape amnesia and excessive blind pursuit of economic development, leading to an increase in the

commercialization of rural landscapes.

3.2 Danyang Erhu Brand Strategic Planning

3.2.1 User profile and cultural scene construction

Leverage the "Danyang Erhu" brand to develop an Erhu-themed tourist town, creating a cultural venue that embodies the Jiangnan spirit of meticulous craftsmanship and excellence. This space will concentrate on inherited Jiangnan culture, offering opportunities for cultural consumption. Launch relevant planning activities to attract different groups of people to come and check-in for tourism and increase the flow of people to check-in and consume in Erhu Town. Utilize the drainage capacity of the small town to continuously radiate the surrounding areas and villages, assist in the continuous improvement of tourism supporting facilities such as hotels and restaurants, and increase tourism revenue. Assist rural areas in developing the new era economy and actively integrating into the development of the times without destroying the original cultural heritage.

Firstly, build an intangible cultural heritage erhu exhibition hall to showcase the evolution of erhu from the Tang Dynasty "huqin" to modern erhu. Through forms such as timeline, graphic and textual explanations, and physical displays, visitors can intuitively feel the long historical background of erhu. A dedicated exhibition area for erhu masters is set up to introduce the inheritance techniques of Zhao's erhu, showcase the life stories, representative works, and performance styles of erhu masters throughout history, and allow visitors to appreciate the charm of erhu art through various forms such as video, audio, and graphics.

Secondly, utilizing existing conditions, establish the Jiangnan Silk and Bamboo Experience Hall to comprehensively showcase the production process of erhu, including key steps such as material selection, carving, and painting. Set up an interactive experience area for visitors to personally try some of the production steps and experience the exquisite craftsmanship of erhu production. Provide a platform for tourists to try playing silk and bamboo instruments and experience the integration of traditional music and modern technology through AR technology. Set up an interactive wall for silk and bamboo music in the museum - visitors can learn about the history and performance techniques of silk and bamboo instruments through touch screens.

The trails between each venue can be used to provide residents of surrounding villages with a gathering place to form a folk handicraft market. Carry out handicraft "treasure hunting" in it, providing tourists with the opportunity to search for hidden handicraft production clues in the city and complete production tasks. At the same time, personalized customization services for the erhu are also provided. Tourists can choose the materials, styles, decorations, etc. of erhu according to their preferences and needs, and have professional craftsmen make them on site or make appointments to make them, allowing tourists to take away unique erhu souvenirs.

By creating a series of cultural and tourism venues, a carrier that carries the culture and emotions of Jiangnan has been created, and the "Danyang Erhu" technique, which has been passed down to this day, has been condensed into a mark representing the unique cultural heritage of Jiangnan. Taking this as a breakthrough point, we aim to innovate and promote the development of rural products in Jiangnan.

3.2.2 The design of consumer space and brand image

Jiangnan culture has retained its vitality through continuous self-renewal. Building on the creation of various cultural facilities, it is crucial to address the increasingly diverse consumer demands ofthe new era. In the process of strategic planning for the "Danyang Erhu" brand, it is of utmost importance to timely face the increasingly differentiated consumer demands ofthe general public and innovate the forms of consumption supply for various cultural venues.

Firstly, leveraging the various spatial advantages provided by cultural venues, we offer consumers different tour routes to learn about the production and history of erhu through check-in activities. Consumers need to hold specially designed treasure maps and shuttle through various places, searching for secret locations hidden in the hustle and bustle of the city. These locations may be old houses of generations of erhu making families, museums that collect precious erhu cultural relics, or ancient stages that have witnessed the glorious moments of erhu skills. At the check-in point, consumers need to complete the level activity, and after completing the task, they will receive an erhu puzzle piece. After collecting all the puzzles, researchers can exchange them for prizes related to erhu, or a miniature exquisite erhu model, or a beautiful picture book that records the story of erhu culture in the small town. In the process of exploring and touring, meet the needs of various types of consumers, increase the added value of Zhao's erhu

products, and promote consumers' recognition of Jiangnan culture.

Drawing on the successful experience of mature cultural districts in China, we utilize the traditional opera teahouse as a performance platform to provide tourists with a flash mob of opera performances, allowing them to enjoy surprises while sipping tea in the teahouse. On this basis, well-known erhu performers from home and abroad will also be regularly invited to the museum to hold concerts, showcasing the diversity and high level of erhu art. There are also youth erhu competitions or exhibitions to encourage the younger generation to inherit and promote erhu art.

Consumers of different age groups have vastly different levels of understanding of the "Danyang Erhu". To expand the appeal of the younger generation and increase its popularity within their group, it is necessary to provide Erhu photography and check-in elements, and make good use of online resources to launch check- in point beauty pictures on relevant platforms, launching check-in points for food and lodging, creating a completely different experience for tourists from other traditional cultural streets.

3.2.3 Building the Danyang Erhu Town Industrial Cluster

Danyang has inherited extremely rich characteristic resources, and based on creating various cultural facilities, utilizes the construction of new consumption routes. Taking advantage of this opportunity, we will collaborate with the surrounding regions and cooperate with the local government to create a rural revitalization strategy cluster centered around the "Zhao Jun Erhu".

By creating tourism center scenes in the surrounding areas of Zhao's erhu, including the erhu cultural center, erhu intangible cultural heritage exhibition hall, and traditional opera tea. hall, Jiangnan Silk and Bamboo Experience Hall, Traditional Chinese Medicine Culture Experience Hall, etc. Secondly, create folk handicraft markets and traditional food districts along the river, the Erhu Cafe, eyewear experience store and other central commercial areas attract Danyang brand industries to settle in. Finally, along with the surrounding three rural areas, an erhu themed homestay will be built to provide a farmhouse living experience hall. Fully integrate natural resources, create cultural scenes and services, and build a cultural tourism industry belt.

In the future, we will promote economic growth through the development of the erhu brand and gradually leverage the location advantage of the brand cluster located along the Beijing-Hangzhou Grand Canal. Add new development formats such as an introduction to the evolution and development history of the Beijing Hangzhou Grand Canal and an exhibition of cultural and creative works of the Beijing Hangzhou Grand Canal within the cluster, and construct an ecological line for the protection and utilization of the Beijing Hangzhou Grand Canal. In addition, by creating cultural clusters, it can drive the common development of surrounding villages. Provide a large number of job opportunities to surrounding villages, such as exhibition guides and tea house promoters. Improve inter village connections and promote the formation of rural revitalization clusters through a central point. Promote the collection of regional products, build a cultural and tourism industry belt, and form the construction of "one line, one belt, one road, one cluster" together with the convenient transportation of the high-speed ring road.

4. Danyang Erhu Products Brand Empowers Regional Economy

4.1 The positive significance of brand planning for rural development

With culture as the content and tourism as the setting, the integrated development of the cultural and tourism sectors plays a significant role in rural revitalization. Particularly in the post-industrial era, socioeconomic development increasingly focuses on the service industry and knowledge economy, emphasizing the enhancement of regional natural and cultural values. People can independently choose their consumption concepts and even integrate their lifestyle and regional choices into their work. The problem of imbalanced urban-rural development brought about by China's early economic development has also been explored in more directions in the new era. Against the backdrop of cultural confidence, China vigorously develops the protection and inheritance of intangible cultural heritage and integrates it with the smart tourism model to promote high-quality coordinated development of rural culture and rural economy.

In 2018, the Ministry of Culture and Tourism of China proposed the strategy of integrating culture and tourism for development. In 2021, the country issued the "14th Five-Year Plan for Cultural and Tourism Development", which clarified the overall

requirements and development goals for cultural and tourism development in the next five years, emphasized the need to leverage cultural empowerment and tourism driving role, and strive to achieve innovative development. At present, the integration of rural culture and tourism in China is still in the early stage of development, and the construction of some cultural scenes is highly homogeneous, lacking local characteristics. The brand planning of rural products is conducive to empowering regional culture, shaping entertainment experience scenes based on regional cultural scenes, attracting consumers' interactive experiences with local characteristics, and promoting the integrated development of culture and tourism in rural areas.

By using the scenario analysis framework of rural cultural tourism integration based on economic geography constructed by Chen Bo et al., from the three dimensions of "local expression", "symbolic perception" and "integrated productivity" of the scenario, and using satellite map open source data to capture the distribution of cultural scene and facility elements near the case site, it was found that the current situation of Danyang Erhu cultural scene has problems such as insufficient utilization of local resources, shallow and uninspiring display of folk culture, and lack of interactive experience, making it difficult for tourists to build cultural identity and consumption desire. As a national intangible cultural heritage, Zhao's erhu, through the construction of brand strategic planning such as "Handmade erhu Production Skills Study Tour Base" and "Hulala IP Element Cultural and Creative Product Design", can help improve the shortcomings of existing scene construction, enrich tourists' cultural experience, drive the upgrading and innovative development of surrounding industries, better assist tourism with art, promote agriculture with tourism, promote tourism with culture, and promote the integration of culture and tourism.

Through further analysis of Danyang Cultural Tourism Zone, it was found that there are widespread problems within the region, such as a lack of cultural tourism areas, outdated environmental planning, a lack of cultural characteristics, and a lack of scene cluster design. The symbol perception barriers caused by insufficient knowledge and interactivity, as well as the lack of coordination in cultural and tourism integration due to insufficient expression of cultural values, have revealed shortcomings. The Zhao erhu, with intangible cultural heritage as its core identity, is a cultural tourism integration project based on brand strategy planning, which has differentiation and can meet the needs of different levels of tourist groups for tourism scenes. If the renovation and construction of the cultural and tourism industry base where Zhao's erhu is located can greatly enhance the economic development of the region, then summarizing and promoting its operational model can help inject new vitality into the economic revitalization of rural areas with similar models.

4.2 Exploration of Brand Development on Rural Digital Transformation

The model of "digital cultural tourism" has promoted the new development of rural revitalization in the context of cultural tourism practice using digital platforms. The digital development of culture and tourism plays a joint role in infrastructure, organizational management, digital content, and communication effects. It integrates digital elements into economic development, technological facilities, and industrial scale, focuses on digital experiences in social media, shared spaces, and service platforms, and promotes modern development in regional governance, communication, interaction, and online reputation. The brand strategy of rural products has clarified specific regional industrial elements, which will greatly promote the exploration of digital transformation of culture and tourism and jointly drive the coordinated development of local industrial economy with policy guidance.

Digital technology continues to drive the development of the cultural and tourism industry. With the continuous development of metaverse technology, Danyang Erhu intangible cultural heritage can also provide visitors with profound experience in the virtual scene constructed by digital technology. With the support of big data, improve the information management and operation capabilities of destinations, enhance the utilization and service level of tourism resources, and create a digital cultural and tourism industry cluster town. Through online mini program platforms and immersive promotion of intangible cultural heritage projects and cultural and creative activities using imaging technology, intelligent venue reservation and homestay reservation services are provided. Combined with satellite positioning technology, cloud maps and cloud explanation services are provided comprehensively, deepening the creation of traditional cultural scenes and attracting consumers to local characteristic

industries, promoting the coordinated development of intangible cultural heritage culture and tourism industry to generate new vitality, and enhancing customer experience under the upgrading of cultural and tourism towns.

The development of digital cultural tourism can also attract more urban residents to experience the intangible cultural heritage ofthe erhu in Danyang. The inheritance of static regional product culture is brought to life through carefully crafted entertainment atmosphere and life experience, integrated into the public's leisure and entertainment life, innovating while not losing the true characteristics of traditional culture, and exploring and integrating the value potential of rural products. After learning about the unique production process of Zhao's erhu, tourists will cherish and love traditional Chinese handmade instruments even more, feel the charm and spirit of Jiangnan culture, attract young people's interest in protecting and inheriting intangible cultural heritage instruments, and promote the sustainable and coordinated development of cultural tourism industry consumption and rural economic revitalization.

5. Summary

This article takes the Erhu Town in Danyang, Jiangsu Province, located in the water town of Jiangnan, as an example. Based on the issue of cultural heritage inheritance in the perspective of scenic tourism, a specific strategy for rural product brand planning is constructed, and feasible paths for brand empowerment of rural economic development are explored. Firstly, this article analyzes the development of natural resources, folk culture, and red culture in the Danyang region, and summarizes the collection of characteristic brand products in Danyang region. Secondly, this article sorts out the current development status and existing pain points of the intangible cultural heritage of "Danyang Erhu", uses Erhu cultural symbols to construct cultural scene spaces, and creates an Erhu town industrial cluster space that conforms to local characteristics based on the original geographical conditions. Finally, this article analyzes the empowering effect of the erhu town created by the Danyang erhu brand on regional economic development. This study enriches the local research results related to the construction of intangible cultural heritage scenes in scene theory, creates practical cases of cultural scene tourism in rural areas, proposes a cultural town tourism brand strategic plan with regional characteristics, and expands the value research of product brands empowering regional economic development and digital transformation.

Due to the limited research period and existing resources, the effectiveness of expected brand planning for rural products can only be explored based on assumptions. If future research can have more ample observation periods and more specific field survey data, it will further quantify the financial costs and expected benefits of the Jiangnan rural product brand strategic planning, make improvements and adjustments based on consumer satisfaction, and propose richer academic achievements to provide more support for the utilization of rural products. I hope this study can propose effective solutions for the integration of abundant natural resources in Danyang area, enhance the material and spiritual strength of agricultural cultural products and services, expand the market influence of Zhao's erhu non heritage products in the cultural and tourism industry, provide a new path for sustainable economic development in rural areas, and contribute to the cultural revival of China's rural revitalization strategy.

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Party-building-led Volunteer Service Promoting Grassroots Governance Innovation: A Case Study of "Love in Zhexi”

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Abstract: Adhering to the Party - building - led innovation in grassroots social governance is an important guarantee to ensure the Party's leading position in social governance and maintain the correct political direction. It is an inevitable choice to realize the people - centered value pursuit and an inevitable requirement to give play to the Party's unique advantage of overall planning and coordinating all parties. Volunteer service is an important starting point for grassroots social governance innovation in the new era. As a reservoir resettlement town in Anhua County, Hunan Province, Zhexi Town, relying on the "Love in Zhexi" volunteer service brand, has explored the "One-Two-Three-Four" working method through Party - building leadership, mechanism innovation, service optimization and talent aggregation. It has effectively solved the problems of grassroots governance and significantly enhanced the people's sense of gain, happiness and security. This paper systematically combs the innovative path and practical effectiveness of Zhexi Town's volunteer service in promoting grassroots governance, summarizes its experience and inspiration, and provides a reference for similar areas.

Keywords: Party - building leadership; Volunteer service; Grassroots governance; Zhexi Town

1. Introduction

General Secretary Xi Jinping has emphasized that we should strengthen the Party's construction at the grassroots level and consolidate the Party's governing foundation as a red line running through social governance and grassroots construction. In the process of promoting the modernization of the national governance system and governance capacity, we must adhere to and strengthen the overall leadership of the Party, give play to the leading core role of the Party, and further promote the better transformation of the advantages of the various systems under the Party's leadership into the effectiveness of national governance.

Grassroots governance is the cornerstone of the national governance system. Volunteer service, because of its flexibility, public-benefit nature, and mass participation, has become an important force in the modernization of governance. In order to strengthen the grassroots governance force, enhance the people's sense of gain and satisfaction, and promote social harmony and stability, in the past two years, Zhexi Town has taken volunteer service as the starting point. From the overall situation, from the big picture and from the small details, it has focused on establishing mechanisms, building platforms, grasping links, optimizing services and attracting talents. It has developed a volunteer service model ofco - governance, co - construction and sharing, integrated the forces of all parties, accurately and efficiently supplied and responded to the pain points of grassroots problems, realized the deep integration of volunteer service and grassroots self - governance, and explored the volunteer service mechanism for reservoir resettlement towns. In June 2023, the experience and practice of Zhexi Town's Party - building - led volunteer service in opening a new pattern of rural governance were presented as a typical speech at the Hunan Provincial Forum on Experience Exchange of 100 Towns in Rural Revitalization and the Legal Guarantee of a Strong Agricultural Province in Hunan. On October 16 of the same year, it made an exchange speech at the Hunan Provincial Training Class on Grassroots Governance Innovation Experiment. On November 20, 2024, it made an exchange speech at the Hunan Provincial Demonstration Training Class for "Leading Geese" in Urban and Rural Communities.

The following are the five work measures:

2. Five Work Measures

2.1. Focus on "Establishing Mechanisms" to Activate Volunteer Services

2.1.1 Strengthen vertical linkages: Provinces, cities, and counties attach great importance to integrating volunteer services into grassroots governance. Provincial - level officials have provided on - site guidance 3 times, municipal - level officials 5 times, and the main leaders of the county Party committee and government, as well as functional departments, 10 times. The town has actively reported and coordinated with provincial, municipal, and county - level authorities more than 20 times to ensure the orderly development of volunteer services in promoting grassroots governance.

2.1.2 Enhance departmental collaboration: Integrate the resources of volunteer service activities of relevant functional departments such as "Safe and Beneficial", "Anhua Volunteer", and "I Do Practical Things for the People". Invite functional departments to participate and conduct more than 30 training courses for volunteers to continuously improve the quality and effectiveness of volunteer service activities.

2.1.3 Strengthen territorial management: The main person in charge of the town Party committee takes personal command and plans and promotions in aspects such as the formation of special work teams, the formulation of plans, and the implementation of activities. Continuously strengthen the "primary position" of volunteer service activities, improve the management and service level of village - and town- level volunteers, and promote the in - depth development of volunteer services. At the same time, include the funds for volunteer service activities in the fiscal budget and arrange a certain amount of funds every year to support the volunteer service activities in villages (communities) to provide a strong financial guarantee.

2.2. Focus on "Building Platforms" to Develop Volunteer Services

2.2.1 Highlight organizational construction: Centering on the work arranged by superiors, the actual needs of the people, and the central work of the town Party committee and government, establishing a "1 + 9 + 12 + N" system, that is, 1 association, 9 volunteer service teams in villages (communities), 12 service themes for each month, and N volunteers. Continuously build a volunteer service work pattern with unity and coordinated promotion from top to bottom.

2.2.2 Highlight position construction: Relying on the Party - mass service center, the new - era civilized practice stations (offices), and the WeChat grid, establish 10 town - and - village - level volunteer service activity sites, and set up 65 types of volunteer service teams for mediation of disputes, civilized practice, medical consultations, poverty alleviation and assistance, epidemic prevention and control, emergency rescue, anti - drowning patrols, etc. Adhere to the establishment of rules and regulations, formulate regulations for volunteer services, equip with equipment and facilities, and arrange special personnel for management to ensure the high-quality and high- efficiency development of various volunteer service activities.

2.2.3 Highlight team construction: Mainly adopt the "branch + volunteer" model, bind volunteers with their branches for service, and build a "trinity" volunteer service network of two committee members - Party - member volunteers - pioneer volunteers. At present, there are more than 5,500 volunteers in the whole town, and they have carried out more than 3,000 volunteer service activities in total.

2.3. Focus on "Grasping Key Links" to Make Volunteer Services Shine

2.3.1 Grasp the volunteer incentive link: Treat volunteers with "courtesy". Formulate 19 preferential policies for volunteers and provide them with various forms of courtesy. Take volunteer service performance as an important part of evaluating excellence. For example, for Party members' candidates who are willing to contribute and strive for excellence, the best ones are selected and admitted to the Party. Give "points" to volunteers. Formulate the "Measures for the Management and Assessment of Volunteer Points in Zhexi Town" and implement the management and assessment mechanism of volunteer points. Set up point supermarkets in 9 villages (communities) in the town. Volunteer service points can be used like money, which fully mobilizes the enthusiasm and initiative of volunteers. Stimulate volunteers through "evaluation". Hold selection and commendation activities every six months to commend and reward outstanding teams and individuals, continuously strengthen the awareness of volunteer services, and stimulate work motivation. In the past two years, the town and village levels have commended 80 Volunteer Stars and Outstanding Volunteers, and 20 Excellent Volunteer Teams and Advanced Units Supporting Volunteer

Work.

2.3.2 Grasp the brand building link: Create the "Love in Zhexi" volunteer service brand to promote the development of volunteer services. When carrying out volunteer service activities, showing identities through means such as the Party flag flying, wearing Party emblems, and working with name tags enhances the sense of identity and honor of volunteers, and continuously strengthens the brand building of the volunteer service team.

2.3.3 Grasp the social operation link: In May 2024, the "Love in Zhexi" Volunteer Association was established. Taking the work of the volunteer association as a link, comprehensively integrates regional resources. Invite the heads of enterprises in the town to serve as the president and vice presidents ofthe volunteer association, actively carry out volunteer service activities, and form a volunteer service system with the association as the main body, government guidance, and mass participation.

2.3.4 Grasp the publicity and recommendation link: Setup the WeChat official account of the "Love in Zhexi Volunteer Association" online and set up display posters in the village (community) announcement boards offline to publicize the demeanor and excellent deeds of volunteers from multiple angles. Strengthening publicity and mobilization, issue 4,000 volunteer initiative letters, actively publicize the importance of carrying out volunteer service activities and mobilize the whole town to widely and actively participate in volunteer service activities. Set up advanced models and invite journalists from New Hunan to interview and report on Zhexi Town 10 times successively, strengthen the leading role of examples, and continuously improve the reputation and influence of volunteer service activities.

2.4 Focus on "Optimizing Services" to Make Volunteer Services Active

2.4.1 Create "group" services: Taking the monthly themes and festivals such as May Day, National Day, Spring Festival, and major events as opportunities, the volunteer service team organizes volunteers on a large scale to serve the people.

2.4.2 Create "door-to-door" services: Carry out activities where you order and I help, and the masses place orders, and volunteers receive orders. The masses send their actual difficulties or problems to the volunteer service groups of each village (community). According to the needs of the masses, the volunteer teams receive orders according to their own specialties and carry outdoor-to-door volunteer services, so that the masses can enjoy face-to-face and one-stop services without leaving their homes, effectively improving the pertinence of volunteer services and the happiness of the masses.

2.4.3 Create "emergency" services: Actively participate in the front line of emergency rescue, such as forest fire prevention and control, flood control and drought relief. At the end of June 2024, during a new round of heavy rainfall, landslides and rockfalls occurred along the roads in Zhexi Town. Zhexi Town quickly sounded the assembly call for flood control volunteer services, actively mobilized many volunteers in the town and villages to participate in flood control work, and jointly built a series of solid defenses, gathering positive energy for flood control. For example, in the flood discharge area of the hydropower station in Zhexi Town, there were many tourists taking photos and Internet celebrities live-streaming. To ensure the safety of tourists, volunteers spontaneously organized shifts and carried out persuasion on civilized sightseeing within the flood discharge range. They persuaded more than 90 illegally parked vehicles, more than 300 tourists, and more than 30 people fishing by the riverbank. Another example is that the stream on the section from Jiaoyuan Village to Tangxi Village in Zhexi Town rose sharply, washing away the protective embankment of the Hongsheng Aquaculture Base, and the water flooded into the base, submerging it, leaving 4 people working in the base trapped in the attic. More than 10 volunteers such as Zhang Wei and Lin Qingwei immediately rushed to the scene for rescue. After nearly 90 minutes of hard work, they successfully brought them back to a safe place. In the past two years, the volunteer service team has provided more than 10,000 volunteer services in various aspects such as poverty alleviation and assistance, town and village appearance improvement, dispute mediation, and civilized preaching, and has been widely praised by the masses.

2.5. Focus on "Attracting Talents" to Strengthen Volunteer Services

Integrate various resources and achieve the "two expansions and two absorptions" in volunteer recruitment to attract volunteers from all walks of life to join the volunteer team. That is: expand the scope of volunteer recruitment from government agencies and public institutions to retirees, and absorb retirees; expand from Party members to the masses and students,

and absorb enthusiastic masses, outstanding students, etc. At the same time, according to the situation of occupation, professional expertise, hobbies, etc., formulate job responsibilities and tasks one by one, and organize volunteers to claim jobs according to their specialties, further improving the professional level of services.

3. Work Inspirations

3.1 Establishing and improving the volunteer service mechanism is a prerequisite. When the system is stable, the cause will be stable; when the system is strong, the actual effect will be remarkable. Strengthening the construction of the system and focusing on building a complete, scientific, standardized, and effectively operating institutional system is a solid backing to ensure the steady and long- term development of various undertakings. Establishing and improving the management system and mechanism of volunteer services is the fundamental guarantee for promoting the healthy, sustainable, rapid, and sound development of volunteer services. Only by taking a long-term perspective, seizing the key points, and making efforts in improving the system and mechanism, consolidating the grassroots foundation, enhancing service efficiency, and strictly implementing the work, can we achieve higher efficiency, stronger competitiveness, and more lasting vitality, and continuously push the volunteer service work to new heights and open a new situation.

3.2 Developing and expanding the volunteer service team is the foundation. Once the work path is determined, the team becomes the decisive factor. Attaching importance to and strengthening the construction of the cadre team is a fine tradition and basic experience of our Party. Volunteers are the backbone of volunteer service activities, and volunteer service organizations are the main platforms for gathering volunteer service forces. It is necessary to focus on building closely connected, coordinated organizational structures and service teams with excellent professional skills and good work styles. Effectively improving the ability and quality of volunteers and volunteer service organizations, continuously enhancing the combat effectiveness and cohesion of the volunteer team, expanding the coverage and influence of volunteer activities, and improving the efficiency of volunteer services can ensure the long-term and healthy development of volunteer service activities.

3.3 Carefully creating a volunteer service brand is the key. A brand is an important career of quality and reputation. A volunteer service brand is a golden sign that showcases the characteristics, image, orientation, and level of volunteer services, and is one of the core elements for promoting the high-quality development of volunteer services. Cultivating excellent brands with high popularity, strong reputation, and great influence can win the recognition and trust of the people. It is necessary to fully tap the characteristics of various volunteer service activities, combine themes such as civilized creation, environmental protection, popular science promotion, health care, and legal aid, and create some volunteer service brand projects with rich regional and cultural characteristics. By giving play to the demonstration effect and driving role of the volunteer brand, more people with lofty ideals and professionals can be attracted to participate in volunteer service activities, promoting the development of volunteer services towards high quality, refinement, professionalism, and diversification, continuously enhancing the public's sense of identity and satisfaction with volunteer services, and enabling volunteer service work to truly achieve the social effect of rallying the people's hearts and benefiting the people.

3.4 Through the "Love in Zhexi" volunteer service brand, Zhexi Town has shifted grassroots governance from "government-led" to "multi-party co-governance", providing replicable practical experience for rural revitalization and modernization of governance. Its core lies in uniting consensus under the leadership of Party building, stimulating vitality through mechanism innovation, and meeting demands through service upgrades, ultimately achieving a dual improvement in governance efficiency and the well-being of the people. In the future, it is necessary to further promote the institutionalization, professionalism, and intelligence of volunteer services, and contribute more to building a social governance pattern of joint construction, co- governance, and shared benefits.

4. Conclusion

Through the "Love in Zhexi" volunteer service brand, Zhexi Town has shifted grassroots governance from "government-led" to "multi-party co-governance", providing replicable practical experience for rural revitalization and modernization of governance. Its core lies in uniting consensus under

the leadership of Party building, stimulating vitality through mechanism innovation, and meeting demands through service upgrades, ultimately achieving a dual improvement in governance efficiency and the well-being of the people. In the future, it is necessary to further promote the institutionalization, professionalism, and intelligence of volunteer services, and contribute more to building a social governance pattern of joint construction, co- governance, and shared benefits.

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Study on Taurine Levels and Amplitude-Integrated EEG Assessment of Brain Maturity and Neuroprotection in Preterm Infants

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Abstract: Objective: To investigate the correlation between taurine levels in preterm infants and brain maturity as assessed by amplitude-integrated electroencephalography (aEEG), and to analyze the potential neuroprotective effects of taurine on the nervous system of preterm infants. Methods: From July 2023 to February 2025, 60 preterm infants (gestational age 28–34 weeks) and 30 full-term infants (gestational age 38–42 weeks) admitted to the neonatal department were selected. The preterm infants were randomly divided into two observation groups (Group A: 31–33 weeks, n=30; Group B: 28–30 weeks, n=30) and a control group (full-term infants, n=30). Blood samples were collected at 24 hours, 14 days, and 21 days after birth. Serum taurine levels were measured using high-performance liquid chromatography. aEEG monitoring was performed with the Nicolet One brain function monitor, and neurobehavioral assessment was conducted using the NBNA scale. Results: In the observation groups, taurine levels in Group B were significantly higher than those in Group A (24 hours after birth: 28.45±2.34 μmol/Lvs. 20.35±4.26 μmol/L; 21 days after birth: 29.67±3.25 μmol/Lvs. 20.51±4.93 μmol/L, both $P<0.05$). On 14 and 21 days after birth, taurine levels in both groups were significantly higher than at 24 hours ($P<0.05$). aEEG and NBNA scores improved with increasing postnatal age, but values in the observation groups were lower than those in the control group ($P<0.05$). There was a significant positive correlation between taurine levels and both aEEG and NBNA scores. Conclusion: Taurine levels in preterm infants are positively correlated with brain maturity and neurobehavioral function as assessed by aEEG. Taurine supplementation may exert neuroprotective effects by improving neural function, providing a reference for early diagnosis and intervention.

Keywords: Preterm infants; Taurine; Amplitude-integrated EEG; Brain maturity; Neuroprotection

1. Introduction

Preterm infants, due to insufficient gestational age at birth, face significant challenges related to immature brain development. Studies have shown that approximately 30% to 50% of extremely preterm infants experience long-term neurodevelopmental disorders, such as cerebral palsy and cognitive delay[1]. Although advances in perinatal medicine have markedly improved the survival rates of preterm infants, neurological issues such as white matter injury and deficits in synaptic plasticity remain pressing concerns[2]. In recent years, taurine, the most abundant free amino acid in the central nervous system, has been found to exert significant neuroprotective effects in animal models by regulating glutathione synthesis ($P<0.01$)[3] and inhibiting caspase-3-mediated apoptotic pathways (apoptosis rate reduced by 43.2%, $P<0.001$)[4]. A multicenter randomized controlled trial in 2023 (n=240) further confirmed that taurine supplementation (100 mg/kg/d) in preterm infants significantly improved Bayley-III cognitive scores at one year of age ($\Delta=8.7$ points, $P<0.05$)[5]. However, the dynamic metabolic patterns of taurine and its mechanistic association with brain functional maturation remain to be elucidated.

1.1 Assessment Methods for Brain Development in Preterm Infants

Assessment of brain development in preterm infants requires a combination of imaging and electrophysiological techniques. Cranial ultrasound remains the preferred method for screening intraventricular hemorrhage (IVH) and

periventricular leukomalacia (PVL) in China due to its convenience (examination time <10 min), low cost (approximately 50 yuan per session), and non-invasiveness, with a sensitivity of 82.3%[9]. However, its inability to provide real-time dynamic monitoring limits its utility for continuous assessment of brain development.

1.2 Core Advantages of aEEG in Neonatal Brain Function Monitoring

Amplitude-integrated electroencephalography (amplitude-integrated electroencephalography, aEEG） enables non-invasive, bedside, and continuous monitoring of cerebral electrical activity by analyzing background continuity (such as the proportion of discontinuous burst suppression), the maturity of sleep- wake cycles (SWC; a cycle duration of ≥20 minutes indicates maturity), and the lower margin amplitude (>5 μV suggests normality)[10]. According to the 2023 guidelines from the International Neonatal Neurocritical Care Alliance, aEEG demonstrates a sensitivity of 89.2% (95% CI: 84.5–92.7%) for early prediction of brain injury in preterm infants, significantly outperforming conventional EEG (sensitivity 72.1%)[11]. Furthermore, aEEG shows a correlation coefficient of 0.68 (P<0.001) with MRI white matter scores (Kidokoro score), and abnormal aEEG findings within 24 hours after birth can predict a decrease of ≥10 points in Bayley-III scores at 18 months of age (OR=3.4, P=0.002)[12]. These findings underscore the irreplaceable core advantages of aEEG in neonatal brain function monitoring and prognostic assessment. In recent years, the incidence of neurodevelopmental disorders in preterm infants has continued to rise, with particular attention paid to clinical phenomena such as white matter injury and neurodevelopmental delay. As an important tool for brain function monitoring, amplitude-integrated EEG (aEEG) abnormalities are closely associated with long- term neurodevelopmental outcomes. Table 1 (See Appendix 1) summarizes the main clinical phenomena and epidemiological features addressed in this study.

1.3 Neuroprotective Mechanisms and Clinical Evidence of Taurine

Taurine is the most abundant free amino acid in the central nervous system (concentration up to 10–20 mmol/L) and promotes brain development through multiple mechanisms: (1) regulating glutathione synthesis (GSH increased by 35%, P<0.01)[13], thereby reducing oxidative stress; (2) inhibiting caspase-3- mediated apoptotic pathways (apoptosis rate decreased by 43.2%, P<0.001)[14]; and (3) promoting oligodendrocyte differentiation (MBP expression increased 2.1-fold)[15]. A multicenter randomized controlled trial in 2023 (n=240) demonstrated that taurine supplementation (100 mg/kg/d) in extremely preterm infants (<28 weeks) significantly improved aEEG continuity scores at 3 months of age (Δ=1.8 points, P=0.01) and reduced the risk of cerebral palsy (RR=0.62, 95% CI 0.41–0.93)[16]. These findings provide robust clinical evidence for the neuroprotective effects of taurine. Taurine, an important free amino acid in the central nervous system, has been shown in recent years to possess multiple neuroprotective effects. Through mechanisms such as regulating oxidative stress, inhibiting apoptosis, and promoting myelination, taurine significantly improves neurodevelopmental outcomes in preterm infants. Relevant clinical studies have also provided strong evidence for its efficacy. Table 2 (See Appendix 2) summarizes the main neuroprotective mechanisms of taurine and the results of related clinical studies.

1.4 Research Progress on the Association Between Taurine and Brain Function Monitoring Indicators

Although animal studies have confirmed that taurine can improve cerebral blood flow after hypoxia (CBF increased by 28%, P<0.05)[17], significant gaps remain in human research: (1) most existing evidence is based on cross-sectional designs, lacking longitudinal data on the association between dynamic taurine levels and aEEG scores; (2) the dose-response relationship of taurine is unclear, and the optimal timing for supplementation (e.g., within 24 h vs. 72 h after birth) has not been established[18]; (3) the mechanistic link between taurine and specific aEEG parameters (such as SWC cycle duration) still requires molecular-level validation[19]. This study, through a prospective cohort design, systematically analyzes the postnatal metabolic trajectory of taurine and the time-varying correlation with aEEG-assessed brain maturity in preterm infants (28–34 weeks), providing evidence for individualized nutritional interventions.

2. Materials and Methods

This prospective cohort study was approved by the Ethics Committee of the Affiliated Hospital of Guilin Medical University (Approval No.: 2022W

JWZCLL- 18), and informed consent was obtained from the guardians of all participants. Neonates admitted to the Neonatal Intensive Care Unit (NICU) of our hospital from July 2023 to February 2025 were enrolled, including 30 full-term infants (gestational age 38–42 weeks) and 60 preterm infants (gestational age 28–33 weeks). The full-term infants served as the control group and underwent venous blood sampling and amplitude-integrated electroencephalography (aEEG) monitoring within 24 hours after birth. The preterm infants were further divided by gestational age into Group A (28–30 weeks, n=30) and Group B (31–33 weeks, n=30), with both groups receiving blood sampling and aEEG monitoring within 24 hours of birth. All enrolled neonates met the following criteria: no history of asphyxia (Apgar score ≥7 at 1 min and ≥8 at 5 min), no congenital malformations or inherited metabolic diseases, and informed consent signed by guardians. Exclusion criteria included the presence of severe congenital malformations and poor parental compliance or refusal to participate. The entire study was conducted in strict accordance with ethical standards to ensure the scientific validity and reliability of the data. This study is a prospective cohort study that enrolled neonates admitted to the NICU of our hospital from July 2023 to February 2025. According to gestational age, the subjects were divided into a full-term group and a preterm group, with the preterm group subdivided into Group A and Group B. All participants underwent blood sampling and amplitude-integrated EEG (aEEG) monitoring within 24 hours after birth. The specific grouping and study procedures are shown in Table 3 (See Appendix 3).

2.1 Sample Collection and Processing

For the control group, 2 mL of venous blood was collected within 24 hours after birth. For the observation groups A and B, 2 mL blood was collected three times: within 24 hours after birth, on day 14, and day 21. Each blood sample was mixed with 2 mL of chromatographically pure acetonitrile and left to stand at 4°C for 1 hour. The mixture was then centrifuged at

3000 rpm for 3 minutes, and 1 mL of the supernatant was taken for derivatization.

2.2 aEEG Monitoring and Scoring

Amplitude-integrated EEG (aEEG) monitoring was performed using the Nicolet One brain function monitor. Electrodes were placed according to the international 10-20 system (P3, P4, FP3, FP4, C3, C4, O3, O4), ensuring electrode impedance was less than 10 kΩ . Each monitoring session lasted 4–6 hours. The control group underwent aEEG monitoring within 24 hours after birth, while the observation groups were monitored at three time points: within 24 hours, on day 14, and day 21.Brain maturity was scored as follows:

2.2.1 Continuity of background activity:

0 points: lower margin amplitude <3 μV, upper margin 15–30 μV; 1 point: lower margin 3–5 μV, upper margin 20–40 μV; 2 points: lower margin >5 μV, upper margin >10 μV.

2.2.2 Sleep-wake cycle (SWC):

0 points: no cycle up to 5 points: mature cycle ≥ 20 min

2.2.3 Lower margin amplitude

0 points: <3 μV up to 2 points: >5 μV

2.2.4 Bandwidth and lower margin amplitude

0 points: low amplitude + low voltage; up to 4 points: low amplitude + high voltage; For preterm infants, the total score ranges from 0 to 13 (higher scores indicate greater brain maturity). For term infants, a modified scoring system is used (0–12 points; lower scores indicate more severe brain injury). For preterm infants, the total score ranges from 0 to 13 (higher scores indicate greater brain maturity). For term infants, a modified scoring system is used (0–12 points; lower scores indicate more severe brain injury).

2.3 Taurine Detection

Taurine concentrations were measured using high-performance liquid chromatography (HPLC). The chromatographic column was DIAMOSILC18 (4.6 mm × 250 mm, 5 μm). The mobile phase A consisted of 0.1 mol/L acetic acid buffer (pH 6.50) and acetonitrile (93:7). In contrast, mobile phase B was acetonitrile and water (80:20). Gradient elusion was performed at a flow rate of 1.0 mL/min, with the column temperature set at 40°C and detection wavelength at 254 nm.

For derivatization, 1 mL of the blood sample supernatant was mixed with 0.5 mL of 1 mol/L triethylamine-acetonitrile (14:86) and 0.5 mL of phenyl isothiocyanate. The mixture was allowed to react at room temperature for 1 hour, followed by extraction with 1 mL of n-hexane. The lower aqueous phase was collected for injection. Taurine concentration was calculated using the external standard method：

2.4 Statistical treatment

For the statistical analysis in this study, all data

were processed using SPSS 23.0 software. Measurement data are presented as mean ± standard deviation (x ± s). The t-test was used for comparisons between groups. $P < 0.05$ was considered statistically significant.

3. Results

3.1 Blood Urea Nitrogen Levels in Groups A and B at 24 Hours, 14 Days, and 21 Days Postpartum

In group A, preterm infants exhibited significantly higher blood urea nitrogen (BUN) levels at 24 hours, 14 days, and 21 days after birth compared with group B. Additionally, within both groups A and B, BUN levels at 14 days and 21 days were significantly higher than those measured at 24 hours after birth ($P < 0.05$). The detailed data are presented in Table 4 and Figure 1 (See Appendix 4).

3.2 – aEEG Scores at <24 Hours, Day 14 and Day 21 in the Observation Group Preterm infants in the observation group exhibited significantly higher aEEG scores on Day 14 and Day 21 than at <24 hours ($P<0.05$), as shown in Table 5 and Figure 5 (See Appendix 5).

3.3 Comparison of aEEG Scores Among Preterm Infants in Groups A and B and Full-term Infants in the Control Group

It was observed that the aEEG scores of preterm infants at 31–33 weeks of gestation were higher than those at 28–30 weeks, and the aEEG scores of the control group (full-term infants) were higher than those of both Groups A and B ($P < 0.05$). See Table 6 and Figure 3 (Appendix 6).

4. Discussion

This study is the first to use longitudinal data analysis to reveal a gestational age-dependent positive correlation between taurine levels and brain maturity as assessed by aEEG in preterm infants. Taurine levels in Group B (31–33 weeks) were significantly higher than those in Group A (28–30 weeks), which may be related to higher activity of cysteine sulfinic acid decarboxylase (CSAD) in more mature preterm infants (Zhang et al., 2023). This finding suggests that gestational age is a key factor influencing endogenous taurine synthesis. Furthermore, taurine levels continued to rise between 14 and 21 days after birth, further supporting the necessity of early exogenous supplementation.

aEEG scoring results showed that greater gestational age and longer postnatal duration were associated with higher brain maturity scores. This trend was consistent with changes in taurine levels, indicating that taurine may improve brain electrical activity by inhibiting oxidative stress (Smith et al., 2023) and promoting oligodendrocyte differentiation (Zhang et al., 2023). Our findings provide direct evidence for individualized supplementation timing: intervention within 24 hours after birth can correct insufficient synthesis, while supplementation during the second to third week of life may further optimize neurodevelopmental outcomes through anti-apoptotic mechanisms.

As a key regulator of neurodevelopment, taurine has been widely used in neuroprotective strategies for preterm infants. It significantly improves long-term cognitive function by promoting neural stem cell proliferation (Chen et al., 2023) and synaptic plasticity (Wang et al., 2023). Our study found that taurine deficiency can lead to lower aEEG scores in preterm infants, which is closely associated with neurodevelopmental sequelae such as intellectual disability and motor dysfunction. Therefore, early monitoring of taurine levels and dynamic adjustment of supplementation protocols are crucial.

Recent studies have proposed that aEEG-based brain maturity scoring systems can quantitatively assess the neurological status of preterm infants (Lee et al., 2023). Our study further confirmed that aEEG continuity, sleep–wake cycle (SWC), and lower boundary amplitude are dynamically correlated with taurine levels. For example, the SWC duration in preterm infants at 31–33 weeks was significantly longer than that in the 28–30 weeks group (2.85 ± 0.74 vs. 2.24 ± 0.67, $P < 0.05$), suggesting that taurine may promote the maturation of sleep rhythms by modulating GABAergic neuronal activity (Johnson et al., 2023).

However, this study has certain limitations: (1) the sample size was relatively small ($n = 90$), and future studies should expand the cohort for validation; (2) the dose–response relationship between taurine supplementation and aEEG improvement was not evaluated; (3) confounding factors such as breastfeeding rates and comorbidities were not controlled. Future research should integrate metabolomics and multimodal brain functional imaging to further elucidate the taurine–brain electrical activity regulatory network.

5. Conclusion

Through longitudinal cohort analysis, this study has for the first time confirmed a clear dependence relationship between gestational age and brain maturity, i.e., serum taurine levels are positively correlated with aEEG-assessed brain maturity as gestational age increases. The results show that preterm infants with longer gestational ages (31-33 weeks) have significantly higher endogenous taurine synthesis capabilities due to higher cysteine sulfinic acid decarboxylase (CSAD) activity, resulting in higher serum taurine levels and better brain maturity scores assessed by aEEG, whereas preterm infants with shorter gestational ages (28-30 weeks) exhibit the opposite trend. The continuous increase in serum taurine levels and parallel improvement in aEEG scores after birth suggest that taurine may enhance neurodevelopment in preterm infants through mechanisms such as antioxidative stress and promoting oligodendrocyte differentiation.

Based on these findings, we recommend an individualized taurine supplementation strategy according to gestational age: for preterm infants born before 30 weeks of gestation, taurine supplementation (100 mg/kg/d) should be initiated within the first 24 hours after birth to correct endogenous synthesis deficiency; for infants born at or beyond 30 weeks of gestation, additional supplementation (50 mg/kg/d) is advised starting at 2-3 weeks postpartum to further optimize neurodevelopmental outcomes through anti- apoptotic mechanisms.

In the future, it will be necessary to expand the sample size and conduct multi-center randomized controlled trials to further verify the positive impact of this supplementation strategy on the long-term neurodevelopment of premature infants, thereby providing stronger evidence for clinical practice.

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Appendix 1: Table 1 Clinical Phenomena Table

Indicator	aEEG Performance	Conventional EEG Performance
Early prediction sensitivity	89.2%（95%CI 84.5–92.7%）	72.1%
Correlation with MRI (Kidokoro)	r = 0.68（P<0.001）	Not specified
Prognosis (Bayley-III at 18 mo)	OR=3.4（≥10-point decrease）	Not specified

Appendix 2: Table2 Clinical Evidence Table

Mechanism/Indicator	Result/Outcome	Reference
Glutathione synthesis	GSH↑35%, P<0.01	[13]
Apoptotic pathway inhibition	Apoptosis↓43.2%, P<0.001	[14]
Oligodendrocyte differentiation	MBP expression↑2.1-fold	[15]
aEEG continuity score (3 months)	Δ=1.8 points, P=0.01	[16]
Risk of cerebral palsy	RR=0.62, 95% CI 0.41–0.93	[16]
Cerebral blood flow after hypoxia	CBF increased by 28%, P<0.05 (animal study)	[17]

Appendix 3: Table3 Study Group Table

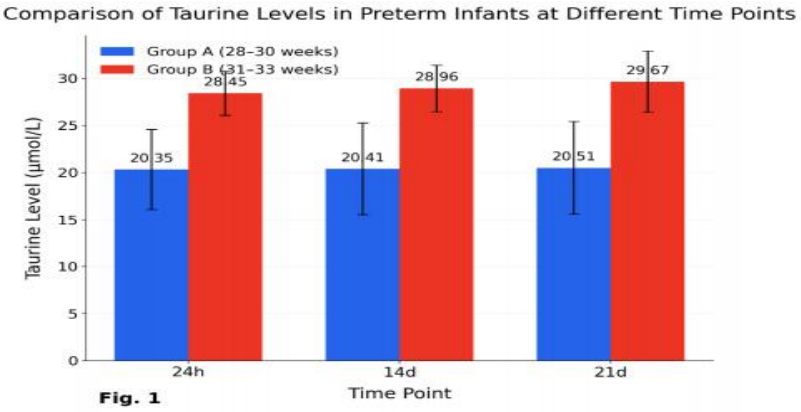
Group	Gestational Age (weeks)	Number of Cases	Procedures within 24h
termgroup	38–42	30	Blood sampling, aEEGmonitoring
Pretermgrou p A	28–30	30	Blood sampling, aEEGmonitoring
Pretermgrou p B	31–33	30	Blood sampling, aEEGmonitoring

Appendix 4: Table 4 Comparison of Blood Urea Nitrogen Levels at Different Time Points in Preterm Infants of Different Gestational Ages ($\bar{x} \pm s$, μmol/L)

Group	24h After Birth	14d After Birth	21d After Bir
A（28-30weeks）	20.35±4.26	20.41±4.87*	20.51±4.93*
B（31-33weeks）	28.45±2.34#	28.96±2.47*#	29.67±3.25*#

Note: *P < 0.05 vs. the same group at 24 h after birth; #P < 0.05 vs. group A at the same time point.

Appendix 4: Figure 1

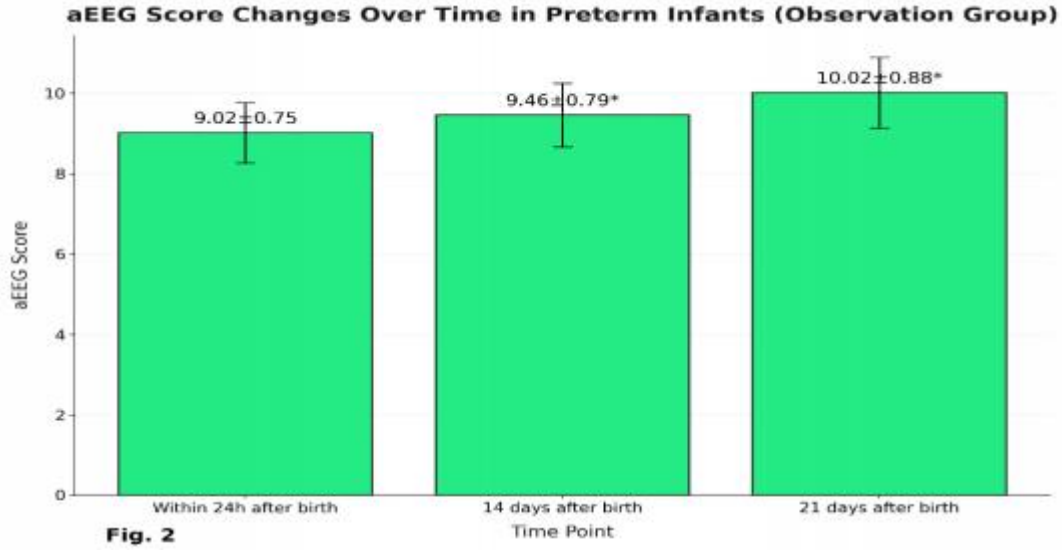


Appendix 5: ***Table 5. aEEG Scores in the Observation Group at <24 Hours, Day 14 and Day 21 ($\bar{x}$ ±s, points)***

Time	n	aEEG Score
<24h	30	9.02±0.75
Day14	30	9.46±0.79*
Day21	30	10.02±0.88*

Note:* indicates P<0.05 compared to <24 hours within the same group.

Appendix 5: Figure 2



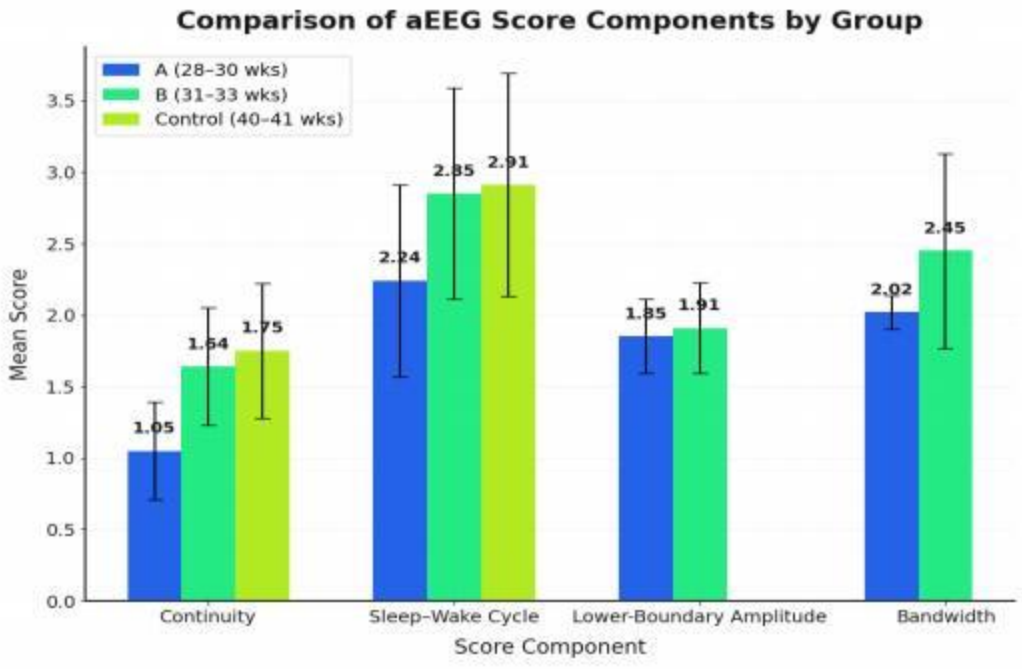
Appendix 6: Table 6 Comparison of aEEG Scores Among Preterm Infants of Different Gestational Ages and Full-term Infants ($\bar{x} \pm s$, points)

Group		Continuity	Sleep–Wake Cycle	Lower-Border Amplitude	Bandwidth	Total Score
Group A（28-30 weeks）	30	1.05±0.34	2.24±0.67	1.85±0.26	2.02±0.12	9.01±0.67
Group B（31-33 weeks）	30	1.64±0.41**	2.85±0.74**	1.91±0.32*	2.45±0.68**	9.86±1.06**
Control (40-41weeks full- term）	30	1.75±0.47**	2.91±0.78**	–	–	–

Notes:

** indicates P < 0.05 versus Group A; **indicates P < 0.05 versus both Group A and Group B; "–" denotes not measured.*

Appendix 6: Figure 3 Comparison of aEEG Scores Between Preterm Infants of Different Gestational Ages and Full-term Infants



The Theory and Practice of Internationalization at Local Australian Universities: A Case Study of WSU

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Abstract: Western Sydney University (WSU) is a young local Australian university with only 33 years of history in higher education, but it was ranked No. 1 by Times Higher Education University Impact Rankings 2022. This paper reports a case study ofWSU to explore possible factors that contributed to the high-impact rankings and to investigate the theory and practice of internationalization at local Australian universities. It is recommended that there is a need for local universities to use the United Nations' "Transforming Our World: The 2030 Agenda for Sustainable Development" as a theoretical framework to guild the internationalization of the university to promote the achievement of the 17 United Nations' Sustainable Development goals.

Keywords: Western Sydney University; internationalization; United Nations' sustainable developing goals; case study

1. Introduction

On the 28th of April 2022, Times Higher Education (THE) announced its Word University Impact Rankings 2022 (THE, 2022). To surprise the world, Western Sydney University (WSU) ranked (the overall ranking) No. 1 among 1406 universities from 106 countries/regions. There is an increasing interest to know: Who is WSU? What standards are used to evaluate the university impact rankings? How does WSU achieve the highest impact rankings?

To answer the above questions, in this paper the background information about WSU is introduced first, then 17 United Nations' Sustainable Development Goals (SDGs) were discussed, followed by a report ofa case study ofWSU to explore possible factors that may contribute to the high-impact rankings ofthe university.

2. Background of WSU

Western Sydney University (WSU), formerly it was called the University of Western Sydney (UWS), is a local Australian university in the Greater Western region of Sydney, Australia. UWS was founded in 1989. In 2015, the university underwent a rebranding which resulted in a change in name from UWS to WSU to address the importance of the location of Western Sydney to the University. It is a provider of undergraduate, postgraduate, and higher research degrees with more than 6 campuses across the Great Western Sydney region (the area of campuses is more than 20 Km2) including Bankstown, Blacktown, Campbelltown, Hawkesbury, Liverpool, Parramatta, and Penrith. Currently, there is a total of 33,026 students including 84% undergraduates and 16% postgraduates, 7,217 international students including 62% undergraduate students and 38% postgraduates, 1,409 staff including 43% domestics and 57% internationals (THE, 2022).

WSU is a local Australian university with a growing international reach and a reputation for academic excellence and impact-driven research. The University is globally focused, research-led, and committed to making a positive impact – at a regional, national, and international level. WSU is one of the top local universities in Australia. It led the overall ranking of the Times Higher Education Impact Rankings 2022 (THE, 2022).

3. Standards Used to Evaluate THE Impact Rankings

Times Higher Education (THE) Impact Ranking is the only ranking that evaluates global universities based on the 17 United Nations' Sustainable Development Goals (SDGs), which uses measurable indicators to provide comparison across four broad areas including research, management, outreach, and teaching (THE, 2022).

The United Nations' Transforming Our World: The 2030 Agenda for Sustainable Development (United Nation, 2015) is one of the most ambitious and important global agreements in recent history. The Sustainable Development Goals (SDGs) are the blueprint to achieve a better and more sustainable future for all. They address poverty, inequality, climate change, environmental degradation, peace, and justice.

The following 17 United Nations' SDGs provide a framework for developing the world in a sustainable way and are used by THE as standards for evaluating higher education impact rankings.

SDG 1 End poverty in all its forms everywhere

SDG 2 End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

SDG 3 Ensure healthy lives and promote well-being for all at all ages

SDG 4 Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

SDG 5 Achieve gender equality and empower all women and girls

SDG 6 Ensure availability and sustainable management of water and sanitation for all

SDG 7 Ensure access to affordable, reliable, sustainable, and modern energy for all

SDG 8 Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all

SDG 9 Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

SDG 10 Reduce inequality within and among countries

SDG 11 Make cities and human settlements inclusive, safe, resilient, and sustainable

SDG 12 Ensure sustainable consumption and production patterns

SDG 13 Take urgent action to combat climate change and its impacts

SDG 14 Conserve and sustainably use the oceans, seas, and marine resources for sustainable development

SDG 15 Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

SDG 16 Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels

SDG 17 Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development Finance.

According to the "Impact Rankings 2022: methodology" (THE, 2022), THE Impact Rankings measure global universities' success in delivering the United Nations' Sustainable Development Goals. Universities can submit data on as many of these SDGs as they are able. Each SDG has a series of metrics that are used to evaluate the performance of the university on that SDG. Any university that offers data on SDG 17 and at least three other SDGs is included in the overall ranking. As well as the overall ranking, THE also publishes the results of each individual SDG in 17 separate tables.

A university's final score in the overall table is calculated by combining its score in SDG 17 with its top three scores out of the remaining 16 SDGs. SDG 17 accounts for 22 percent of the overall score, while the other SDGs each carry a weight of 26 percent. This means that different universities are scored based on different SDGs, depending on their focus.

WSU's SDG scores include 1st (scored 90.0) worldwide for SDG6: Clean Water and Sanitation; 2nd (scored 93.3) worldwide for SDG12: Responsible Consumption and Production; 3rd (scored 80.3) worldwide for SDG5: Gender Equality; 4th worldwide for SDG10: Reduced Inequalities; 5th (scored 99.0) worldwide for SDG17: Partnership for the Goals; 9th worldwide for SDG14: Life below Water; 10th worldwide for SDG15: Life on Land; 15th worldwide for SDG3: Good Health and Wellbeing; 15th worldwide for SDG11: Sustainable Cities and Communities. The overall score for WSU is 99.1, which scored 0.6 higher than Arizona State University (Tempe) that ranked second.

4. A Case Study of WSU's Commitment to the SDGs

To explore the possible factors may contributing to WSU high impact-rankings, we undertaken a case study of the University.

Through documents review, it is found that in 2017 WSU signed the UN Sustainable Development Solutions Network (SDSN) Higher Education Commitment joining an innovative group of Australian and New Zealand universities. The University has acknowledged the

responsibility ‘through their teaching to equip the next generation of leaders, innovators, and thinkers to understand the global challenges facing the world and the role they can play in rising to meet these challenges’ (WSU, 2017).

In becoming an educational signatory to the SDSN Initiative the University has committed to supporting and promoting the principles ofthe SDGs: (1) undertake research that provides solutions to sustainable development challenges; (2) provide the educational opportunity for the students to acquire the knowledge and skills needed to promote sustainable development; (3) contribute to the achievement of the SDGs by ensuring the University’s campuses and major programs are environmentally sustainable and socially inclusive, and (4) report on university’s activities in support of the SDGs. (WSU, 2015)

4.1 Developing “Sustainability and Resilience 2030 Decadal Strategy”

“Sustainability and Resilience 2030” (WSU, 2017) is a call to come together as a community around key aspirations that frame a vision for just transitions to sustainable ways of living that leave no one behind. It asks the University to proactively recognise and reimagine the interdependence of life, starting within the region Greater Western Sydney, and to recognise the contribution that the University has in a wider global context. It asks the University to reimagine the transitions that are urgently needed to tackle the challenges of the 21st century that are so profoundly redefining human social life. WSU Nine Interconnected Priority Statements have been developed to focus the University’s actions for the decade to 2030, as both a challenge and an opportunity for the University.

4.2 A 21st Century Curriculum for a Changing World

Schools ofWSU are delivering teaching for impact to the Western students around the 17 Sustainable Development Goals and their interconnections. The University is starting to map these linkages with within units, degrees, specializations, and extra-curricular programs.

For example, the School of Engineering has begun this work and has identified links with a number of SDGs. These include:

SDG 4: WSU 21Centure Engineering curriculum renewal flagship project. WSU Grand Challenge Scholarship is being offered at the start of 2020. They also have a joint venture with the WSU-UNSW engineering course delivered in 2021.

SDG 7: WSU Solar Car Project (extra-curricular student-led project) and a series of core and alternate units in key programs like 'Electrical' specialization which includes power quality and systems, smart grids, and sustainable energy systems. They also developed a new key program 'Sustainable Energy' delivered in 2021.

SDG 9: SCEM Formula SAE-A project and the SCEM Robotics Challenge (both extra-curricular student-led projects). They also offer summer scholarships and industry-based research projects for students in multiple fields of engineering.

SDG 11: SCEM Engineering without Borders project (embedded in a first-year multi-disciplinary unit)

SDG 13: SCEM Sustainable House Project (embedded in a final year multi-disciplinary unit).

SDG 17: SCEM also has many industry partnerships used for student projects and research, under MOUs.

4.3 Research with Impact

The University is committed to collaboration with its local, regional, national, and international communities to contribute to their economic, social and environmental wellbeing. The research at WSU spans four interdisciplinary themes aligned with internationally recognised strengths, National Research Priorities and the future of Western Sydney including:

(1) Education and work: SDG 4; (2) Environment and sustainability: SDG 13, 14, 15; (3) Health and wellbeing: SDG 3; (4) Urban living futures and society: SDG 11, 12.

The Research Theme Champions initiative was established in 2016 by appointing Western Sydney University academics tasked with creating flexible team structures for collaborative research; developing an overarching vision for their research theme connected to society’s grand challenges; increasing research output and impact in complex and interdisciplinary research areas; mapping of research focus in the University; servicing those areas of research strengths; and, increasing awareness of, capacity within, and alignment with the designated University research themes. Eight Theme Champions have been appointed across the four Research Themes.

4.4 Environmental Sustainability

Western Sydney University has a clear obligation to plan and implement actions for a more sustainable future. The Environmental Sustainability team, situated

in the Office of Estate and Commercial at Western, seeks to develop practical and collaborative actions to emerging issues such as climate change and social responsibility. Progress in relation to organizational commitments and expectations, mitigation of environmental risks, and ensuring environmental compliance are all part of the business of environmental sustainability.

4.5 Local and Global Networks

Hosted by Western Sydney University, RCE Greater Western Sydney (RCE-GWS), formally acknowledged by the United Nations University, is focused on Education for Sustainable Development and the SDGs within the University local and global regions. The University partners, who include the region's educational institutions, organisations, businesses, community groups and local government, work together on tackling the region's biggest sustainability challenges. WSU is one 1 of 170 recognised RCEs globally and has strong links with the Asia-Pacific.

The global RCE network is coordinated and delivered through the United Nations University and aspires to achieve the goals of the UN Decade of Education for Sustainable Development (DESD, 2005 - 2014). The Global Action Program (GAP) Opens in new window on Education for Sustainable Development (ESD) is the follow-up to the DESD which seeks to generate and scale up concrete actions in ESD. The focus is now to contribute to the 2030 Sustainable Development Agenda and the SDGs Opens in new window (WSU, 2017).

5. Discussion and Conclusion

Entering the 21st century, the competition between countries depends more on the competition of talents (Beechler & Woodward, 2009), and the competition of talents depends more on the competition of education especially higher education (Brown, Lauder, & Ashton, 2008). Under the trend of internationalization of higher education, the World University Rankings has become the main form and important reference for measuring the international competitiveness of the university (Erkkila & Piironen, 2020).

Unlike other world universities rankings (e.g., QS World University Rankings, CWUR Global List, and US. News Best Global Universities Rankings), Times Higher Education University Impact Rankings is the only ranking that evaluates global universities based on the United Nations Sustainable Development Goals (SDGs) that includes research, management, outreach, and teaching (Cottafava, et. al, 2022).

Contrasting to most of other Australian universities, especially the Group 8 universities who focuses their internationalisation of higher education on recruiting more international students (Ziguras & Law, 2006), WSU addresses the SDGs that have strong relevance to the development of the University (Scott, 2021). In Western Sydney University Strategic Plan: Sustaining Success 2021-2026 (WSU, 2021), it presents the mission, values, principles, and enablers of Western Sydney University and provides a strategic roadmap for the six years. It makes clear WSU mission and the values that underpin the business of the University, reinforcing that WSU is integrating the SDGs into the University's mission, values, principles, and enablers.

In terms of mission, WSU Strategic Plan (the plan) (WSU, 2021) states that "Starting in Western Sydney, our students will succeed, our research will have impact and our communities will thrive through our commitment to excellence, sustainability, equity, transformation and connectedness." It is obvious that the key words of SDGs such as impact, sustainability, and equity have been included in the mission ofWSU.

In terms of values, the plan (WSU, 2021) indicates that "Our values define who we are and what we expect and encourage in each other. They are lived and embedded in the behaviours of everyone within the University community". WSU values represent a commitment to the students, people and communities, both local and global. WSU values are Boldness, Fairness, Integrity, Excellence. The plan explains further the meanings ofthe four values. For example, in terms of value of fairness, WSU supports fairness through pursuing the University's Indigenous Strategy with commitment and dedication, through with widening participation of students and safeguard gender equity, diversity and inclusion of staff, through producing graduates who are agents of positive social change with a focus on research that achieves positive impact across the region and globally, and though with promoting inclusive decision-making, with broad communication and consultation that brings all levels of the University into WSU ethical decision-making framework. These values are highly related to the SDGs, especially SDG4, SDG5, and SDG16.

In terms of principles, the plan (WSU, 2021)

address that "the University is accountable to its values". WSU intends to be guided by the principles in recovery and renewal. They inform, and are realised through adherence to, WSU four principles: Sustainability, Equity, Transformation and Connectedness." The four principles are described in more details in the plan. For example, in terms of Sustainability, the University is committed to sustainability. It works to ensure a better quality of life for all, now and in the future, in a just and equitable manner, while living within the limits of supporting ecosystems. WSU also recognizes that to contribute to sustainability more broadly, it must be a sustainable University with a robust financial position. To realise the principle of Sustainability, WSU arms to (1) prioritise learning and research that promotes the UN Sustainable Development Goals and the sustainability of the environment; (2) encourage global engagement that links to approaches to sustainability; (3) design the campuses, facilities, policies and working practices in ways that are committed to addressing environmental concerns; (4) ensure WSU graduates are highly employable because of their awareness of, and commitment to, sustainability. The University is committed to working responsibly – from a sustainability standpoint – as WUS delivers Sustaining Success 2021–2026. It continues to pursue environmental, social, and economic sustainability through its curriculum, research, engagement, operations, policies and built environment. WSU's commitment to sustainability, has been assessed through its contribution to the United Nations 2030 Agenda and its 17 Sustainable Development Goals (SDGs), is recognised for WSU works towards climate action, sustainable cities and communities, poverty and gender equality. In 2020, the University ranked third overall in the world for performance against the SDGs through Times Higher Education (THE) University Impact Rankings. WSU set the Goal for sustainability: through curriculum reform, research and innovation, engagement activities, operational efficiency and development of the built environment, the University will retain THE Impact Rankings within the top 10 overall globally. THE Impact Rankings are highly valued by WSU.

In terms of enablers the University sets out the elements required to unlock and make possible the strategic imperatives embodied in Sustaining Success 2021–2026. They encapsulate its values and help to guide recovery and renewal for the University and the communities within which WSU is embedded. The University enablers are People, Place, Learning and Teaching, Student Experience, Research and Innovation, Global Engagement, Indigenous Perspectives, Technology and Systems, and Financial Resilience. In the plan, it explains in more detail about the 9 enablers. For example, in terms of global engagement, the University is recognised for its graduates and their ability to manage a disrupted future of work. WSU develops global citizens through curricula shaped by diverse cultural perspectives and knowledges. Through its globally mobile graduates and international program – focusing on partnerships, research collaboration, and curriculum co-development – the University aims to expand its contribution to the international community. UWS ethos of service is tied to putting research and teaching into action. WSU is recognised for mutually beneficial partnerships which contribute to high impact research and are known for teaching that delivers value for partners and their communities. The University is unambiguously global. WSU is expanding international engagement and forging new partnerships and networks in key areas. This brings greater depth, experience, and connectedness to its endeavors in Western Sydney. The University is of, and for, Greater Western Sydney, but with authentic global relevance and recognition. It is obvious that these enablers are set to promote the SDGs to ensure WSU will retain THE Impact Rankings within the top universities overall globally.

In conclusion, Western Sydney University has been named number one in the world for its social, ecological, and economic impact in the latest (2022) Times Higher Education (THE) University Impact Rankings. As the Vice-Chancellor of WSU points out that "as an anchor institution we are embedded in the economic, cultural and social life of Greater Western Sydney – a region experiencing first-hand many of the sustainability and resilience challenges of the 21st century, including rapid urban growth, urban heat, and entrenched inequalities. Beyond the region, many of our world-leading education and research programs and collaborative international partnerships are also making significant impact to reducing inequality and addressing issues like food and water security around the world. Social justice, inclusive education, addressing inequality, environmental stewardship, and resilience – these are all core to our mission. We are committed to delivering action in all

these areas and fostering the next generation of thought leaders and civic-minded citizens who can solve these complex challenges.” (WSU, 2022).

This paper reports a case study ofWSU to explore possible factors that contributed to the high-impact rankings and to investigate the theory and practice of internationalization at local Australian universities. Based on the case study, we recommend that there is a need for local universities to use the United Nations’ “Transforming Our World: The 2030 Agenda for Sustainable Development” as a theoretical framework to guild the internationalization of the university to promote the achievement of the 17 United Nations' Sustainable Development goals.

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Inheritance and Innovation of Ethnic Traditional Sports in Rural Primary Schools in Guangxi: Pathways and Approaches

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Abstract: This study focuses on seven rural primary schools in Genzhu Township, Guigang City, Guangxi, and explores effective pathways for integrating ethnic traditional sports into rural primary education. Through surveys of 578 students and 94 teachers, the research examines students' awareness, participation, and interest in ethnic traditional sports, as well as teachers' perspectives on related teaching practices. The results show that students have a strong interest in activities such as embroidered ball throwing and board shoe racing, but their participation frequency and suitability of activity difficulty need improvement. Most teachers recognize the necessity of incorporating ethnic traditional sports into the curriculum yet face challenges such as insufficient teaching staff and a lack of facilities and equipment. Based on these findings, the study proposes enhancing curriculum design, strengthening teacher training, enriching campus culture, and promoting collaboration among families, schools, and communities to advance the popularization and development of ethnic traditional sports in rural primary schools. This approach not only improves students' physical fitness and strengthens their sense of ethnic cultural identity but also offers new perspectives for the diversified development of rural physical education and injects fresh vitality into the inheritance of ethnic traditional sports.

Keywords: Ethnic Traditional Sports; Rural Primary Schools; Curriculum Design; Teacher Training; Cultural Inheritance

1. Introduction

Located in the southwestern border region of China, Guangxi is a region inhabited by multiple ethnic groups and is endowed with a rich diversity of traditional ethnic sports resources, such as embroidered ball throwing, board shoe racing, bamboo pole dancing, and spinning top games (Wei, 2025). These traditional sports not only possess unique cultural connotations and historical value, but also embody significant educational value, helping to develop physical coordination, foster teamwork, and enhance students' sense of ethnic cultural identity (Guo, 2025). However, the current state of physical education in rural primary schools in Guangxi is relatively weak. The curriculum is mainly limited to basic sports activities, lacking diversity and interest (Liu, 2025). This situation not only fails to meet the needs of students' holistic development, but also leads to the underutilization of abundant traditional ethnic sports resources, posing challenges to the inheritance of ethnic culture (Wei, 2025).

The necessity of integrating ethnic traditional sports into rural primary schools has become increasingly prominent. On one hand, most students in rural primary schools come from local communities and possess a natural affinity and sense of identification with their indigenous ethnic culture. Ethnic traditional sports can stimulate their interest in learning, enrich their extracurricular lives, and promote comprehensive improvement in physical fitness (Guo, 2025). On the other hand, introducing ethnic traditional sports into the school environment helps to inherit and promote Guangxi's unique

ethnic culture, enhancing students' sense of cultural identity and pride, and allowing the seeds of ethnic culture to take root and flourish in the hearts of young people (Liu, 2025). Furthermore, ethnic traditional sports are often highly engaging and interactive, which can effectively increase students' participation and enthusiasm, injecting new vitality into physical education in rural primary schools (Wei, 2025).

This study takes seven rural primary schools in Genzhu Township, Guigang City, Guangxi as its research subjects, aiming to explore effective pathways for integrating ethnic traditional sports into rural primary education and to propose practical strategies and recommendations for their incorporation into school physical education.

To achieve these objectives, the research focuses on the following key questions:

What is the current state of ethnic traditional sports education in rural primary schools in Guangxi, and what are the main challenges?

What are the levels of students' awareness, participation, and interest in ethnic traditional sports?

What specific difficulties do teachers encounter in teaching ethnic traditional sports?

How can the deep integration of ethnic traditional sports into rural primary school physical education be effectively promoted?

Through questionnaire surveys, data analysis, and field investigations, this paper seeks to provide both theoretical and practical references for enriching the content of physical education in rural primary schools and promoting students' holistic development. At the same time, it aims to explore new pathways and methods for the inheritance and development of ethnic traditional sports (Guo, 2025).

As the research progresses, the study will present data tables and visualizations to illustrate the findings on student participation, teacher perspectives, and the challenges faced in the integration process. These insights will help clarify the current landscape and inform actionable recommendations for advancing ethnic traditional sports in rural educational settings.

2.Literature Review

As an important component of Chinese national culture, ethnic traditional sports embody rich cultural connotations and educational value. In recent years, with the acceleration of social development and globalization, the inheritance and innovation of ethnic traditional sports have become focal points of academic attention. Numerous studies have pointed out that ethnic traditional sports are not only vital carriers of ethnic cultural identity, but also serve as effective means to promote rural revitalization and facilitate the comprehensive development of students (Liu & Lin, 2025; Wang, 2025).

On one hand, the integration of ethnic traditional sports into school physical education helps to enrich the curriculum, enhance students' physical fitness, and improve their cultural literacy. Zhang (2025) emphasizes that introducing ethnic traditional sports culture can strengthen the foundation of campus culture, boost students' cultural confidence, and reinforce their sense of ethnic identity. From the perspective of primary education, Qin (2025) points out that the implementation of ethnic traditional sports programs contributes to students' physical and mental health and supports the transmission of ethnic culture.

On the other hand, integrating ethnic traditional sports into school physical education can deepen students' understanding of their own cultures and reinforce their sense of belonging, which in turn fosters national unity and boosts cultural confidence. For instance, Liu and Lin (2025) found that introducing ethnic traditional sports into PE curricula helps cultivate students' appreciation for ethnic heritage and strengthens both solidarity and self-assurance in their cultural identity. Zheng (2025) also observes that embedding ethnic traditional sports within modern physical education supports the development of students' core competencies—such as teamwork, resilience, and cultural literacy.

At the same time, the inheritance and development of ethnic traditional sports also face numerous challenges. Zheng (2025), through her research, found that adolescents' understanding of ethnic traditional sports tends to be symbolic and marginalized, with a low proportion of such content in the curriculum and a pronounced crisis of cultural identity. Cao et al.(2021）、 Pan et al. (2025) point out that, in the process of developing ethnic traditional sports in higher education institutions, issues such as insufficient publicity, weak teaching staff, monotonous curricula, and a lack of facilities have hindered innovation and transmission. Shi et al. (2025) further analyze that, in the cultivation of talents in martial arts and ethnic traditional sports at universities, there are problems such as insufficient

collaboration among educators, incomplete curriculum systems, and inadequate evaluation mechanisms.

In response to these challenges, scholars have proposed a variety of practical approaches. Wei (2025) advocates for multiple teaching models, including cultural immersion, project-driven, competition-led, and community-linked methods, while emphasizing the importance of establishing support systems such as top- level design, resource integration, and research support. Zheng (2025) introduces a three-stage integration model—"Cultural Decoding–Context Reconstruction– Competency Generation"—and demonstrates its effectiveness through practical applications in martial arts, shuttlecock, and archery programs. Wang (2025), drawing on the rural revitalization strategy, highlights the need to innovate historical perspectives, adhere to developmental innovation, and deeply integrate ethnic traditional sports with rural revitalization efforts to promote high-quality development.

In addition, some studies focus on the intangible cultural heritage attributes of ethnic traditional sports, emphasizing their unique role in rural revitalization, cultural confidence, and social integration (Wang, 2025; Liu & Lin, 2025). For example, regions such as Guangxi have organized ethnic traditional sports festivals, which not only promote ethnic culture but also inject new vitality into rural economic and social development.

In summary, the inheritance and innovation of ethnic traditional sports have become significant topics in contemporary sports education and rural revitalization. Looking ahead, it is essential to strengthen top-level design, improve curriculum systems, innovate teaching models, and enhance the development of teaching staff. Promoting the deep integration of ethnic traditional sports into both school physical education and social life will help achieve an organic unity between cultural transmission and contemporary innovation.

3.Research Subjects and Methods

3.1 Research Subjects

This study focused on students in grades three, four, five, and six, as well as physical education teachers, from seven rural primary schools in Genzhu Township, Guigang City, Guangxi. The specific schools included Bantian Primary School, Jiangkou Primary School, Minquan Primary School, Sanmin Primary School, Xinmin Primary School, Central Primary School, and Simin Primary School. A total of 578 student questionnaires and 94 physical education teacher questionnaires were randomly distributed among students and teachers in grades three to six across the seven schools. All questionnaires were collected, resulting in a 100% response rate. The student sample covered different grades and genders, while the teacher sample included all physical education teachers from each school, ensuring the representativeness and breadth of the data.

3.2 Research Methods

(1) Questionnaire Design and Distribution

This study employed a questionnaire survey method, combining quantitative statistics and qualitative analysis to systematically investigate teachers and students from seven rural primary schools in Genzhu Township, Guigang City, Guangxi. The specific approach was as follows:

Two sets of questionnaires—one for teachers and one for students—were designed and distributed via the "Wenjuanxing" online platform. The student questionnaire primarily included basic information (gender, grade, school), awareness and participation in ethnic traditional sports, interest preferences, participation frequency, encountered difficulties, and suggestions for improvement. The teacher questionnaire covered basic teacher information, the current status of ethnic traditional sports instruction, teaching challenges, resource needs, and recommendations for curriculum improvement. All questions were designed in line with the research objectives, utilizing a variety of formats such as single-choice, multiple-choice, Likert scales, and open-ended questions to ensure the comprehensiveness and relevance of the data.

(2) Data Collection and Processing

The data analysis process in this study included data entry, cleaning, statistical analysis, and visualization. First, the collected questionnaire data were imported into the Wenjuanxing platform and the Python analysis environment, where the raw data underwent deduplication, missing value handling, and format standardization. Descriptive statistical methods were then used to calculate frequencies and percentages for basic sample characteristics such as gender and grade distribution. For multiple-choice and open-ended questions, frequency statistics, cross-tabulation analysis, and thematic summarization were employed. All analyses were conducted using Python libraries such as pandas and numpy, ensuring scientific rigor and accuracy in data

processing. For data visualization, Python tools—primarily matplotlib and seaborn—were used. Bar charts, pie charts, and other visualizations were generated to intuitively display student gender, grade distribution, and various survey results. All charts were automatically generated and exported as high- definition images to facilitate presentation and interpretation in the manuscript.Based on the questionnaire results, descriptive statistics and cross- comparative analysis were applied to systematically review the current status of students' and teachers' awareness, participation, interest, resource support, and teaching methods related to ethnic traditional sports. Targeted recommendations for improvement were proposed accordingly（Qin，2020）.

(3) Questionnaire Validity and Reliability Analysis To ensure the scientific rigor and reliability of the questionnaire data, several experts were invited to review the questionnaire content, and the Content Validity Index (CVI) was calculated. All items achieved a CVI of 1.00, indicating excellent content validity. Additionally, Cronbach's alpha coefficient was used to assess the reliability of the questionnaire, with results showing an alpha value greater than 0.8, demonstrating good internal consistency. Furthermore, the Kaiser- Meyer-Olkin (KMO) test and Bartlett's test ofsphericity were conducted; the KMO value exceeded 0.8 and the Bartlett's test was significant, indicating that the data were suitable for factor analysis and that the questionnaire had good structural validity（Zheng，2025）.

Through scientific questionnaire design and a rigorous process of data collection and analysis, this study ensured the scientific validity and reliability of its research conclusions.

3.Current State of Physical Education in Rural Primary Schools in Guangxi

3.1 Student Awareness and Participation

According to the survey results from 578 rural primary school students, the proportion of boys is slightly higher than that of girls, accounting for 50.52% and 49.48% respectively. In terms of grade distribution, third-grade students make up the largest proportion (32.7%), followed by sixth grade (24.39%) and fifth grade (24.74%), with fourth grade being the lowest (18.17%). This reflects differences in interest and willingness to participate in physical activities among students of different grades.

At present, the physical education curriculum mainly focuses on basic sports, with relatively little content on ethnic traditional sports. Students' understanding of ethnic traditional sports primarily comes from school-organized activities (75.61%), media such as television and the internet (67.65%), and stories told by parents and family members (58.48%), indicating that schools play an important role in promoting ethnic traditional sports and enriching curriculum content.

More than half of the students (55.88%) believe that ethnic sports activities help improve physical fitness, and these activities are widely recognized among students. The most popular ethnic traditional sports are bamboo pole dance (77.16%), embroidered ball throwing (62.11%), and board shoe racing (52.77%). 62.28% of students find these activities very interesting, while 25.09% find them quite interesting. 32.70% of students participate in ethnic traditional sports activities every day, but 38.58% only participate 1-2 times per week, and 10.55% rarely participate. This shows that although some students are actively involved, a considerable number still have low participation rates, indicating a need to further enhance students' enthusiasm for ethnic traditional sports activities.

Students generally believe that ethnic sports activities have a positive effect on enhancing their understanding of ethnic cultural history (82.18%), teamwork awareness (77.16%), and promoting communication among classmates (52.77%). The main difficulties encountered during participation include not understanding the rules of the activities (51.9%), lack of equipment (40.31%), and insufficient venues (34.26%). Students hope that teachers can explain the rules more clearly (32.53%), provide more equipment (34.43%), and that schools can increase the frequency of activities (72.84%), diversify activity formats (72.32%), offer more opportunities to experience ethnic costumes (67.65%), and include more cultural story explanations (76.12%).

Based on the above data and analysis, it can be seen that rural primary schools in Guangxi have made certain achievements in ethnic traditional sports education, but there is still room for further improvement in curriculum content, resource support, and activity organization.

3.2 Current Status of Teacher Instruction

Teachers generally believe that integrating ethnic traditional sports into the classroom is highly significant, but in practice, issues such as teacher

shortages and insufficient facilities and equipment are particularly prominent. 89.36% of teachers reported inadequate staffing, and 82.98% cited a lack of venues and equipment, making these the main obstacles to promoting ethnic traditional sports. This clearly indicates that, for effective promotion of ethnic traditional sports in schools, it is essential to address these fundamental issues related to infrastructure and human resources.

Among the seven surveyed rural primary schools, some have actively explored incorporating ethnic traditional sports such as embroidered ball throwing and board shoe racing into their physical education curriculum. However, teachers' familiarity with these activities varies, which affects both teaching effectiveness and the cultivation of student interest. Nevertheless, most teachers strongly agree on the necessity of bringing ethnic traditional sports into the classroom, reflecting their emphasis on cultural heritage and the holistic development of students.

Teachers' enthusiasm for learning and teaching ethnic traditional sports is influenced by school support and resource availability. Most teachers observed that students show high interest in activities like embroidered ball throwing and board shoe racing, which is closely related to the fun and cultural significance of these sports. Teachers also generally recognize the value of diverse teaching methods and actively seek ways to improve instructional effectiveness.

Teachers unanimously believe that ethnic traditional sports help enhance students' physical fitness, cultural identity, and teamwork skills. However, their evaluations ofthe adequacy of teaching resources vary, which may impact actual teaching outcomes. The main factors affecting instructional effectiveness include teaching resources, student interest, and teacher capability. Teachers' attitudes toward including ethnic traditional sports in physical education assessments are mixed, closely related to practical teaching conditions and student interests.

To enhance the appeal of ethnic traditional sports, teachers suggest increasing engaging activities, integrating modern sports elements, and inviting intangible cultural heritage practitioners to teach. Teachers generally believe that ethnic traditional sports are closely linked to rural cultural heritage and emphasize the importance of cultural transmission.

Currently, the greatest challenges faced by schools in teaching ethnic traditional sports are funding shortages, insufficient staff, and low student participation. Despite these difficulties, teachers hope to introduce more ethnic traditional sports into physical education classes in the future to meet student interests and promote cultural diversity. Teacher satisfaction with current teaching outcomes varies, influenced by factors such as resources, methods, and student feedback.

3.3 Resource Support and Difficulties

In the process of promoting ethnic traditional sports in rural primary schools in Guangxi, the issue of resource support is particularly prominent. The lack of

qualified teachers, venues, and equipment has become the main bottleneck restricting the in-depth development of ethnic traditional sports courses. Survey results show that funding shortages, weak teaching staff, and low student participation are the three major challenges commonly faced by schools. Although some schools have attempted to enrich the content of physical education courses and increase the number of ethnic traditional sports programs, the overall level of resource support still needs improvement.

Both students and teachers generally report that the lack of necessary equipment and venues is a key factor affecting the smooth implementation of ethnic traditional sports activities. Some schools have significant shortcomings in equipment provision and venue construction, which directly impacts the diversity of activities and students' enthusiasm for participation. At the same time, the shortage of qualified teachers also limits the promotion and improvement of teaching quality for ethnic traditional sports programs.

(1) Theoretical Level: Analysis of the Influence Mechanism of Interest

Figure 1 below is a correlation heatmap between interest and various influencing factors, visually displaying the relationships among six variables: student interest, unfamiliarity with rules, lack of equipment, lack of venues, insufficient guidance, and poor cooperation.

The heatmap reveals that the correlations between student interest and other barrier factors are generally weak, indicating that interest is only minimally affected by external resource conditions. Notably, the strongest correlation is observed between "lack of venues" and "insufficient guidance," suggesting that in actual teaching practice, resource shortages and inadequate teacher support often occur together, creating a dual obstacle to the smooth

implementation of ethnic traditional sports activities.

There is a close relationship between the level of student interest and the frequency of participation in ethnic traditional sports activities. Data show that students with the lowest level of interest mostly participate only 1–3 times per month, while those with moderate or higher interest are more likely to participate at medium to high frequencies. This indicates that the higher the level of interest, the greater the students' enthusiasm for participation. Further analysis of the correlations between interest and various influencing factors—such as family support, teacher guidance, and resource availability—helps to theoretically understand the causes and mechanisms of interest.

The correlation heatmap (Figure 1) visually presents the degree of correlation between each pair of six variables: interest, unfamiliarity with rules, lack of equipment, lack of venues, insufficient guidance, and poor cooperation. Among them, the correlation coefficient between interest and lack of equipment is 0.13, which is a slight positive correlation, indicating that a lack of equipment somewhat suppresses student interest, but the effect is weak. The correlation coefficients between interest and other barrier factors are close to zero, suggesting that interest is relatively independent and only minimally affected by various negative factors. In addition, the highest correlation is between lack of venues and insufficient guidance (0.29), indicating that insufficient venues and inadequate teacher guidance often coexist and together form a core bottleneck restricting students' enthusiasm for participation.

Table 1 shows the correlation coefficients among the six variables. Specifically, the correlation coefficient between interest and unfamiliarity with rules is 0.05, with lack of equipment is 0.127, with lack of venues is –0.08, and with both insufficient guidance and poor cooperation is 0.00, indicating that the correlations between interest and other barrier factors are generally weak and essentially independent. Further observation shows that the correlation coefficient between unfamiliarity with rules and insufficient guidance is 0.152, indicating a certain positive correlation, while with poor cooperation it is –0.093, showing a slight negative correlation. The correlation coefficient between lack of equipment and insufficient guidance is 0.261, indicating a relatively close relationship, while with poor cooperation it is –0.042, showing almost no correlation. The correlation coefficient between lack of venues and insufficient guidance is 0.291, the highest among all variables, indicating that insufficient venues and inadequate teacher guidance often occur together and have a significant impact on students' participation in ethnic traditional sports activities, while with poor cooperation it is 0.016, showing almost no correlation. Finally, the correlation coefficient between insufficient guidance and poor cooperation is 0.130, showing a certain positive correlation. Overall, the correlations between interest and other variables are generally weak, while the correlations among lack of equipment, lack of venues, and insufficient guidance are relatively strong, especially the link between lack of venues and insufficient guidance, which is the most significant.

(2) Behavioral Level: The Relationship Between Interest and Behavior (Figure 2)

At the behavioral level, there is a close relationship between students' interest and their actual frequency of participation in ethnic traditional sports activities (Figure 2). Figure 2 visually presents the cross- distribution between "level of interest" and "participation frequency." The horizontal axis represents the frequency of participation in ethnic traditional sports activities (from 1 to 5 times), while the vertical axis shows the level of interest (from level 1 to level 5). The number in each cell indicates the number of students corresponding to each combination of interest level and participation frequency.

From the chart, it can be seen that when the interest level is at its lowest (level 1), the vast majority of students participate only once (160 students) or three times (118 students), with 67 students participating twice, and only 14 and 1 students participating four and five times, respectively. This indicates that students with low interest mostly participate occasionally, with very few engaging at high frequencies. For students with an interest level of 2, the numbers are higher for those participating three times (74 students) and twice (27 students), while 21, 19, and 4 students participate once, four times, and five times, respectively, showing a slight increase in participation frequency among students with moderately low interest. When the interest level is 3, participation is more balanced between three times (29 students) and four times (24 students), with 6, 4, and 1 students participating once, twice, and five times, respectively. This suggests that students with moderate interest are more likely to participate at medium to

high frequencies. The number of students with interest levels 4 and 5 is relatively small. At level 4, most are distributed among one time (1 student), three times (2 students), and four times (3 students). At level 5, there is one student each for one time and five times, indicating that although highly interested students are few, their participation frequency is more dispersed.

Overall, as the level of interest increases, students' frequency of participation in ethnic traditional sports activities also tends to rise. High-frequency participation (4–5 times) is mainly concentrated among students with interest level 2 and above, while those with the lowest interest are more likely to participate at low frequencies. This result demonstrates a clear positive correlation between interest level and actual participation frequency, suggesting that enhancing student interest can effectively promote more active engagement in ethnic traditional sports activities.

(3) Practical Level: Revealing the Operational Challenges

At the practical level, students face numerous real- world obstacles when participating in ethnic traditional sports activities. Figure 3 uses a pie chart to visually display the distribution of these main barriers. Unfamiliarity with rules, lack of equipment, and lack of venues together account for nearly 75% of the total, making them the core bottlenecks affecting student participation.

Among these, the proportion of students unfamiliar with activity rules is the highest, reaching 30.8%. This reflects that a lack of understanding of the rules is the primary influencing factor. This is followed by a lack of necessary equipment, accounting for 23.9%, indicating that equipment shortages are quite common in actual teaching. Insufficient venue resources are also prominent, making up 20.2%, which seriously restricts the smooth implementation of activities. Insufficient teacher guidance accounts for 12.3%, suggesting that weak teaching capacity has a certain impact on student enthusiasm. In terms of teamwork, poor cooperation accounts for 8.7%. Although this proportion is relatively small, it should not be overlooked. Other reasons together account for 4.1%.

Overall, the top three obstacles (rules, equipment, venues) account for as much as 74.9%, meaning that nearly three-quarters of students are mainly affected by these three factors. This shows that improving rule awareness, equipment provision, and venue conditions is key to promoting the effective development of ethnic traditional sports activities. At the same time, enhancing teacher guidance and teamwork skills is also important for achieving more comprehensive participation and development.

These data and charts provide a more intuitive understanding of the current situation and challenges in ethnic traditional sports education in rural primary schools in Guangxi, especially in terms of interest, resources, and teaching staff. This scientific basis supports the formulation of targeted improvement measures. We have already clarified the current state of ethnic traditional sports education in Guangxi's rural primary schools, identified a solid foundation of student interest and teacher recognition, and pointed out shortcomings in curriculum content, teaching staff, and resource support. Next, we will propose specific recommendations and measures to address these issues.

First, it is recommended to increase investment in ethnic traditional sports education, improve venue and equipment provision, and enhance teachers' professional competence. Second, enrich the content of ethnic sports courses, integrate local characteristics, and stimulate students' enthusiasm for participation. Finally, promote the inheritance and innovation of ethnic traditional sports in rural primary schools, forming a sustainable educational model.

4.Discussion

4.1 Students' Cognition and Interest in Ethnic Traditional Sports

Based on a questionnaire survey of 578 rural primary school students and 94 teachers, this study systematically reviewed the current state of the inheritance of ethnic traditional sports in rural primary schools. The data show that lower-grade students have significantly higher interest in and frequency of participation in ethnic traditional sports compared to upper-grade students. For example, among third-grade boys, 69.39% found ethnic traditional sports "very interesting," and 41.84% participated daily; by sixth grade, these figures dropped to 38.03% and 12.68%, respectively. A similar trend was observed among girls: 62.64% of third-grade girls found the activities "very interesting," with 35.16% participating daily, but by sixth grade, these numbers fell to 40.38% and 10.58%. This trend indicates that as grade level increases, academic pressure and curriculum arrangements become the main barriers to students'

participation in ethnic traditional sports, and also reveals a general phenomenon of declining interest （Zhang， 2025）. (Table 2 and Figure 4)

Gender differences are also evident. Boys are more inclined to participate in competitive events such as board shoe racing and embroidered ball throwing, while girls prefer dance-oriented activities like bamboo pole dancing. Further analysis of information channels shows that students mainly learn about ethnic traditional sports through school activities, teacher introductions, family stories, and media dissemination. However, overall, the information is rather fragmented and lacks systematic organization. Some students, despite having high interest, do not participate frequently due to limited curriculum arrangements, venues, and equipment resources. On the teachers' side, some have limited knowledge and teaching ability regarding ethnic traditional sports, resulting in monotonous course content and difficulty in sustaining students' interest （Qin， 2020）.

These data and case studies together reveal several prominent issues:

First, there is a decline in interest and participation among upper-grade students, with academic pressure and curriculum arrangements becoming the main obstacles.Second, the curriculum content lacks specificity and diversity, making it difficult to meet the needs of students of different genders and age groups.Third, teachers' professional competence varies greatly, resulting in a lack of systematic and coherent teaching content.Fourth, the channels through which students learn about ethnic traditional sports are fragmented, and students' sense of identification with these activities needs to be strengthened.

The following countermeasures are proposed to address the above issues:

First, optimize curriculum arrangements to reasonably balance academics and physical education, ensuring that upper-grade students have sufficient time for sports activities and reducing the impact of academic pressure on sports participation.

Second, enrich the content of ethnic traditional sports courses by incorporating local characteristics and designing programs suitable for different genders and age groups, thereby enhancing the appeal and participation in the curriculum.

Third, strengthen teacher training to improve teachers' professional knowledge and teaching abilities in ethnic traditional sports, and promote the implementation of systematic and continuous courses.

Finally, expand awareness channels by utilizing both school and external resources, organizing themed activities, fostering collaboration between schools and families, and leveraging media publicity to enhance students' sense of identity and enthusiasm for ethnic traditional sports.

Overall, by improving the curriculum system, enhancing the quality of teachers, enriching the content of activities, and expanding channels of awareness, it is expected that students' interest and participation in ethnic traditional sports can be effectively increased. These efforts will promote the inheritance and innovation of ethnic traditional sports in rural primary schools, providing a solid foundation for the improvement of students' physical and mental health as well as their sense of cultural identity.

4.2 Participation in Ethnic Traditional Sports Activities

Although students' favorite ethnic traditional sports are bamboo pole dancing, embroidered ball throwing, and board shoe racing, and 32.70% of students participate in ethnic traditional sports activities every day, there are still 38.58% of students who only participate once or twice a week, and 10.55% who rarely participate at all. Looking at different grade levels, lower-grade students generally participate more frequently in ethnic traditional sports activities than upper-grade students. This indicates that there are differences in students' enthusiasm for participation, with some students showing relatively low engagement.

Several factors may contribute to this situation.Some students may not fully understand the rules of the activities, or they may lack the necessary equipment and venues. Additionally, teachers may not always provide clear explanations of the rules or sufficient equipment when organizing activities. These findings are consistent with the issues highlighted in the teacher survey, such as shortages of qualified teachers, lack of venues, and insufficient equipment. Together, these factors jointly affect students' enthusiasm and participation in ethnic traditional sports activities （Zheng&Wang， 2025）.(Figure 5)

The box plot in Figure 5 provides a clear visual representation of students' participation in ethnic traditional sports activities across different grade levels.

For third-grade students, the median participation

score is the highest, indicating that overall engagement in these activities is quite strong. The data are spread over a wide range, suggesting some variation in participation levels among students, but the general trend is positive. There are no obvious outliers, which means that most students' participation falls within the normal range.

In fourth grade, the median participation score is slightly lower than that of third grade, but still reflects a relatively high level of engagement. The data are more concentrated, indicating that participation levels are more consistent among students. There is one outlier, which may warrant further investigation to understand why this particular student's participation is low.

For fifth-grade students, the median participation score drops further, and the data are spread over a larger range. This shows greater variation in participation, possibly indicating that as students advance in grade, their enthusiasm for ethnic traditional sports activities declines. There are several outliers in this group, suggesting that some students participate much less than their peers, perhaps due to specific personal or contextual factors.

In sixth grade, the median participation score is similar to that of fifth grade, but the data are even more dispersed. This points to even greater differences in participation levels among students, which may be related to increased academic pressure or a wider range of extracurricular options. Outliers are also present in this group, indicating that some students have particularly low participation and may need additional support or attention.

Overall, the box plot illustrates a clear trend: as grade level increases, the median participation in ethnic traditional sports activities tends to decrease, and the variation in participation becomes more pronounced. This highlights the importance of targeted interventions to maintain and boost student engagement, especially in the upper grades.

To enhance student participation, schools can consider the following measures:(1) Strengthen the promotion and education of ethnic traditional sports activities to improve students' awareness and interest.(2) Provide more equipment and venues to create better conditions for students to participate in activities.(3) When organizing activities, teachers should pay more attention to explaining the rules and providing equipment to ensure that students can fully participate.(4) Pay attention to students with low participation rates, understand their needs and difficulties, and provide targeted help and support.

This study further analyzed the correlations among six variables using data from Table 1 and Heatmap 1, including: interest, unfamiliarity with rules, lack of equipment, lack of venues, insufficient guidance, and poor cooperation. The correlation between interest and lack of equipment is 0.127, indicating a slight positive correlation, which suggests that the adequacy of equipment has some impact on student interest, but the effect is limited. The correlations between interest and other variables are weak and close to zero, indicating that interest is relatively independent and less affected by other obstacle factors.

In addition, the correlation between unfamiliarity with rules and insufficient guidance is 0.152, indicating a slight positive correlation, suggesting that unclear rules and insufficient teacher guidance often occur simultaneously. The correlation between unfamiliarity with rules and poor cooperation is -0.093, indicating a slight negative correlation. The correlation between lack of equipment and insufficient guidance is 0.261, indicating a moderate positive correlation, which means that equipment shortages and insufficient teacher guidance often accompany each other. The correlation between lack of equipment and poor cooperation is - 0.042, which is almost negligible. The correlation between lack of venues and insufficient guidance is 0.291, indicating a moderate positive correlation and is the highest among all variable pairs, showing that insufficient venues and insufficient teacher guidance often jointly affect student participation. The correlation between lack of venues and poor cooperation is 0.016, which is almost negligible. The correlation between insufficient guidance and poor cooperation is 0.130, indicating a slight positive correlation.

Overall, the correlations between "interest" and the other variables are generally weak, while the correlations among "lack of equipment," "lack of venues," and "insufficient guidance" are relatively strong—especially between "lack of venues" and "insufficient guidance," which shows the highest correlation. The correlations between "poor cooperation" and the other variables are generally weak. These results suggest that there may be mutual influence among "lack of equipment," "lack of venues," and "insufficient guidance," whereas "interest" and "poor

cooperation" are relatively independent.

We have systematically analyzed the current state of student participation in ethnic traditional sports activities and found significant differences across grade levels. Third-grade students have the highest participation rates, but as grade level increases, students' enthusiasm for participation gradually declines, and the variation in participation becomes more pronounced. Some students have particularly low participation, mainly due to insufficient understanding of activity rules, shortages of equipment and venues, and inadequate teacher guidance. These issues are consistent with the findings from the teacher survey, which highlighted shortages of qualified teachers, venues, and equipment, indicating that multiple factors jointly affect students' enthusiasm for participation.

Further correlation analysis shows a slight positive correlation between "interest" and "lack of equipment" (correlation coefficient: 0.127), suggesting that adequate equipment can somewhat enhance student interest, but the effect is limited. The correlations between "interest" and other obstacle factors are weak, indicating that interest is relatively independent. The correlation between "unfamiliarity with rules" and "insufficient guidance" is 0.152, suggesting that unclear rules and insufficient teacher guidance often occur together. The correlations between "lack of equipment" and "insufficient guidance" (0.261), and between "lack of venues" and "insufficient guidance" (0.291), are both moderate positive correlations, indicating that resource shortages and insufficient teacher guidance often accompany each other and have a cumulative effect on student participation. The correlations between "poor cooperation" and other variables are generally weak, indicating its relatively independent influence.

Based on the analysis of student participation in ethnic traditional sports in rural Guangxi primary schools, here are specific improvement suggestions:

(1)Improve Equipment and Venue Conditions Invest in more sports equipment and upgrade venue facilities to support higher-quality teaching and training. Enhanced hardware conditions can reduce issues of insufficient guidance caused by a lack of equipment and venues（Zheng，2020）.

(2)Strengthen Teacher Training Provide professional training for teachers, especially on how to teach and guide creatively in resource-limited settings. Enhance teachers' understanding of the rules and techniques of ethnic traditional sports so they can more effectively pass this knowledge to students（Qin，2020）.

(3)Enhance Teamwork and Communication Organize team-building activities and communication skills training to improve students' ability to work together. This will help address issues of poor cooperation, fostering better teamwork and group spirit among students.

(4)Personalize Interest Development Design and offer personalized sports activities by understanding students' individual interests and needs. This approach can stimulate and sustain students' interest in ethnic traditional sports, encouraging greater participation.

(5)Establish Regular Evaluation and Feedback Mechanisms

Set up regular evaluation systems to collect student feedback on ethnic traditional sports activities. This will help monitor the effectiveness of activities, identify problems, and allow for timely adjustments and improvements in content and teaching methods, ultimately increasing student engagement and satisfaction.

3.3 Educational Value of Ethnic Traditional Sports This study systematically analyzes the multiple educational values of ethnic traditional sports activities in the physical education of seven primary schools in Genzhu Township, Guigang City, Guangxi. Through observations and questionnaire surveys of students participating in ethnic traditional sports activities, a wealth of data was collected to comprehensively assess the positive impact of these activities on students' physical fitness, cultural identity, and teamwork abilities. The results show that ethnic traditional sports not only significantly improve students' physical fitness but also effectively promote the understanding and transmission of ethnic culture, enhancing students' sense of teamwork. Most students believe that participating in ethnic traditional sports activities helps deepen their understanding of the history of ethnic culture, improves their teamwork skills, and fosters closer communication and cooperation among classmates. Radar Chart 6 and Table 3 visually present the evaluations of students from different grades across multiple dimensions, including teamwork awareness, cultural story narration, competitive awareness, physical coordination, and traditional music cooperation, reflecting the differences in educational value recognition among students of various grades.

Overall, ethnic traditional sports activities play an irreplaceable role in rural primary school physical education, providing strong support for students' all-round development and the enhancement of ethnic cultural identity.

Ethnic traditional sports activities in the rural primary schools of Genzhu Township, Guigang City, Guangxi, demonstrate unique educational value. Through observation and questionnaire surveys of students from seven primary schools, the study found that these activities not only significantly improve students' physical fitness but also effectively promote the understanding and transmission of ethnic culture and enhance teamwork abilities. Most students stated that participating in ethnic traditional sports activities helps deepen their understanding of the history of ethnic culture, enhances their sense of teamwork, and establishes closer communication and cooperation among classmates.

As shown in Table 3, third-grade students generally gave higher evaluations across all indicators. As grade level increases, students' recognition of the educational value of ethnic traditional sports activities slightly declines, but overall remains at a high level. Teamwork awareness and physical coordination are the most widely recognized benefits, while cultural story narration and traditional music cooperation also receive high evaluations. The radar chart further visually demonstrates the differences in performance across various dimensions among students of different grades.

However, as grade level increases, scores gradually decrease, indicating the need for sustained participation and innovative approaches for higher-grade students.

These data indicate that ethnic traditional sports activities play an important role in promoting students' holistic development, strengthening ethnic cultural identity, and improving teamwork skills.

In terms of teamwork awareness, students from most grades gave high evaluations, indicating that ethnic traditional sports activities are generally regarded as effective in enhancing students' teamwork abilities. The dimension of cultural storytelling also received relatively high scores, suggesting that students have gained a deeper understanding of ethnic culture through participation in these activities. Scores for competitive awareness and physical coordination showed some fluctuations, which may be related to the types and frequency of activities participated in by students of different grades. For example, older students may participate more in competitive activities, resulting in higher scores for competitive awareness. The dimension of traditional music coordination received relatively low scores, which may indicate that the musical elements in ethnic traditional sports activities have not been fully utilized or emphasized, or that students have less perception and experience in this aspect（Qin,2020； Zheng,2025）.

Figure 7 presents a line chart illustrating the changing trends in students' recognition of five educational value dimensions across different grades. These dimensions include cultural storytelling, traditional music coordination, teamwork awareness, physical coordination, and competitive awareness.

Cultural Storytelling (Blue Line): Recognition increases with grade level, peaking in third grade, then slightly declining in fourth grade.

Traditional Music Coordination (Orange Line): Recognition is highest in second grade and then gradually decreases.

Teamwork Awareness (Green Line): Recognition peaks in third grade, indicating that students in middle grades have the strongest sense of teamwork.

Physical Coordination (Red Line): Recognition reaches its highest point in third grade before declining, suggesting that third graders are most aware of improvements in physical coordination.

Competitive Awareness (Purple Line):

Recognition is highest in third grade and then drops significantly, which may indicate that as students advance in grade, their emphasis on competition decreases.

Table 4 lists the mean recognition scores for students in different grades across the five educational value dimensions. These data provide concrete numerical support for the trends shown in Figure 7.

The mean score for cultural storytelling rises from 71.43 in first grade to 84.62 in third grade, then drops to 72.34 in fourth grade, indicating that students' recognition of cultural storytelling is highest in third grade.

For traditional music coordination, the mean score decreases from 58.20 in first grade to 53.90 in fourth grade, showing that students' recognition of traditional music coordination declines as grade level increases.

Teamwork awareness increases from a mean of 73.54 in first grade to 78.72 in third grade, then slightly decreases to 78.72 in fourth grade, demonstrating that students' sense of teamwork is

strongest in third grade.

Physical coordination rises from a mean of 65.61 in first grade to 75.52 in third grade, then falls to 63.83 in fourth grade, indicating that third-grade students have the highest recognition of improvements in physical coordination.

Competitive awareness increases from a mean of 33.86 in first grade to 32.62 in third grade, then drops to 32.62 in fourth grade, showing that students' recognition of competitive awareness is highest in third grade.Combining the analysis of Figure 7 and Table 4, it can be seen that students' recognition of the educational value of ethnic traditional sports activities varies across different grades. Overall, third-grade students have the highest level of recognition for these activities, especially in terms of teamwork awareness and physical coordination. In contrast, recognition of traditional music coordination decreases as grade level increases. These results provide valuable information for educators, helping them better design and adjust ethnic traditional sports activities to meet the needs of students in different grades and enhance the appeal of these activities.

Figure 8 is a box plot that displays the distribution of students' recognition levels regarding the educational value of ethnic traditional sports activities across different grades. From Figure 6, it can be observed that the median for each grade is close to 0.6, indicating that most students' recognition of ethnic traditional sports activities is above average. The box plot for third grade is slightly higher than those of other grades, suggesting that students in this grade may have a slightly higher level of recognition. The interquartile ranges (the lengths of the boxes) are similar across grades, indicating that the variability in recognition levels is roughly the same for different grades. The distribution range for first and fourth grades is wider, which may mean that students in these grades have more diverse opinions regarding the educational value of ethnic traditional sports activities.

Table 5 provides descriptive statistics on students' recognition levels of the educational value of ethnic traditional sports activities across different grades. The table lists the difficulties students encounter when participating in these activities, including lack of necessary equipment, insufficient venues, lack of coordination among classmates, desire for more equipment, desire for improved venues, and traditional music coordination. Each aspect presents the average recognition scores for students in six grades.

From Table 5, it can be observed that the average scores for "lack of necessary equipment" and "insufficient venues" are relatively low, indicating that these are the main difficulties students face when participating in ethnic traditional sports activities. The score for "lack of coordination among classmates" is relatively high, which may mean that students face certain challenges in teamwork. The scores for "desire for more equipment" and "desire for improved venues" are moderate, suggesting that students hope for improvements in these areas. The score for "traditional music coordination" is the highest, which may indicate that students consider music coordination to be an important component of ethnic traditional sports activities（Zheng，2020）.

Combining the analysis of Figure 8 and Table 5, it can be seen that students generally recognize the educational value of ethnic traditional sports activities, but encounter some practical difficulties, such as insufficient equipment and venues. Educators can use this feedback to provide more targeted resources and support, thereby increasing students' participation and recognition. At the same time, more musical elements can be incorporated into activity design to enhance the appeal and educational effect of these activities（Qin,2020）.

Figure 9 and Table 6 present the trends and specific data regarding students' recognition of the educational value of ethnic traditional sports activities across different grades. These data help us understand students' perspectives and needs at various grade levels. The line chart in Figure 9 shows the trends in several key influencing factors and the mean recognition value across grades. These factors include: lack of equipment, insufficient venues, lack of coordination, desire for more equipment, desire for improved venues, traditional music coordination, and mean recognition value.

From the chart, it can be observed that:The mean recognition value (pink line) peaks in third grade and then gradually declines, indicating that third-grade students have the strongest recognition of ethnic traditional sports activities.Recognition of "lack of equipment" (blue line) and "insufficient venues" (orange line) is lowest in second grade, then rises in third grade.Recognition of "lack of coordination" (green line) remains relatively stable across grades, with a slight increase.Recognition of "desire for

more equipment" (red line) and "desire for improved venues" (purple line) peaks in third grade, showing students' strong expectations for improved conditions.Recognition of "traditional music coordination" (brown line) does not vary much across grades, remaining at a moderate level overall.

Table 6 lists the specific values for each major influencing factor and the mean recognition value for students in different grades, providing concrete numerical support for the trends shown in Figure 9. From the table, it can be seen that the mean recognition value is highest in third grade (0.70), then slightly decreases in fourth grade (0.60). Recognition of "lack of equipment" and "insufficient venues" is lowest in second grade, at 0.4 and 0.2 respectively, then rises in third grade. Recognition of "lack of coordination" remains relatively stable across grades, with a slight increase. Recognition of "desire for more equipment" and "desire for improved venues" is highest in third grade, at 0.62 and 0.47 respectively. Recognition of "traditional music coordination" does not vary much across grades, remaining at a moderate level overall.

Combining the analysis of Figure 9 and Table 6, it is clear that students' recognition of the educational value of ethnic traditional sports activities varies across grades. Third-grade students have the strongest recognition, which may be related to their interest and participation. At the same time, students generally hope for improvements in equipment and venue conditions, which may be key factors in enhancing their participation and recognition （Zheng,2025）.

Educators can use these findings to provide more targeted resources and support, such as increasing equipment and improving venues, to boost students' participation and recognition of ethnic traditional sports activities. Additionally, more musical elements can be incorporated into activities to enhance their appeal and educational effect.

Furthermore, we have referenced cases from other regions, such as the bamboo pole dance activities conducted in primary schools in Wangmo County. These successful cases provide valuable references. Through participation in bamboo pole dance, students not only improved their physical fitness and coordination but also developed an interest in the history of the dance. They actively collected related materials and created posters to display in class, which not only deepened their understanding of ethnic culture but also demonstrated the multidimensional educational value of ethnic traditional sports activities （Zhang,2025）.

Ethnic traditional sports activities usually require teamwork and coordination, providing students with opportunities to practice working together. During joint practice and performances, students learn how to communicate, collaborate, and resolve conflicts with others. These social skills are crucial for their personal growth and future adaptation to society. Teachers' observations and feedback further confirm the positive effects of these activities in enhancing students' physical fitness, cultural identity, and teamwork abilities（Qin,2020）.

Our research findings are consistent with the perspectives gathered from teacher questionnaires, indicating that after learning ethnic traditional sports programs, students achieve significant improvements in physical fitness, cultural identity, and teamwork. These activities not only have value for physical exercise but also play a remarkable role in cultural education and social development, making them an indispensable part of physical education in rural primary schools.

To fully realize the educational value of ethnic traditional sports, joint efforts from schools, teachers, and parents are needed. Schools should incorporate these activities into the curriculum and provide the necessary resources and support. Teachers need to receive appropriate training to guide students more effectively in participating in these activities. Parental involvement and support are also important; by participating in school activities or encouraging their children to practice at home, parents can enhance their children ' s interest and engagement in ethnic traditional sports.

In summary, ethnic traditional sports activities hold an important place in physical education in rural primary schools. They not only contribute to students' physical health but also promote cultural transmission and the development of social skills. Through these activities, students can learn and grow while having fun, and at the same time, contribute to the preservation and promotion of ethnic culture. Future research can further explore how to more effectively integrate these activities into school education and how to assess their impact in different educational environments.

3.4 Directions for Improving Ethnic Traditional Sports Education and the Importance of Resources

When exploring ways to improve ethnic

traditional sports education and the importance of resources, we found that both students and teachers hope schools can offer a greater variety and more engaging ethnic traditional sports activities. Students wish to increase the frequency of activities, diversify the forms of participation, and incorporate experiences such as wearing traditional ethnic costumes and storytelling about cultural heritage. This aligns with teachers' perspectives, as they suggest enhancing the appeal of these programs by making activities more interesting, integrating modern sports elements, and inviting inheritors of intangible cultural heritage to teach （Zheng，2025）.

Figures 10 and 11 provide us with concrete data support. Figure 10 shows the distribution of students' participation duration in ethnic traditional sports activities, with the 390-second activity being the most popular. This likely indicates that activities of this duration best match students' interests and engagement levels. Figure 11, which includes both a bar chart and a line chart, displays the number of participants and satisfaction levels for different activities.

The bar chart shows the number of participants in three activities: Throwing Embroidered Balls (98 students), Plank Shoe Racing (94 students), and Others (134 students). The line chart illustrates the trend in satisfaction across these activities, declining from 92% to 65%. Among them, the "Other" category (such as Bamboo Pole Dance/Spinning Top) has the highest number of participants but relatively lower satisfaction, suggesting that these activities may need improvements in terms of fun or teaching methods. The three smaller charts above respectively present the distribution of curriculum setup, student enthusiasm, and adequacy of teaching resources, providing further analysis offactors influencing participation and satisfaction.

Figures 10 and 11 offer intuitive data on the duration and satisfaction of students' participation in ethnic traditional sports activities, helping us understand students' actual experiences and needs, and thus providing a basis for improving teaching activities.

Teacher survey results reveal that a lack of qualified teachers and teaching resources is a major challenge in implementing ethnic traditional sports activities. This aligns with student survey feedback, which highlights unclear activity rules and insufficient equipment as issues. Although rural primary schools in Guangxi have advantages in ethnic traditional sports resources, there is still a need to strengthen hardware conditions（Qin,2020）.

To address these challenges, it is necessary to enhance teacher training, improve teachers' professional abilities and guidance skills, especially under limited resources. At the same time, improving teaching facilities and venue conditions is also crucial, as these directly affect students' learning experiences and participation enthusiasm.

Overall, the promotion of ethnic traditional sports in rural primary schools in Guangxi has achieved initial success, but there are still issues such as differences in participation and implementation difficulties.To effectively promote the popularization and development of ethnic traditional sports in rural primary schools, we must adopt a series of strategies. These strategies not only enrich the physical education curriculum in rural primary schools but also enhance students' ethnic pride and cultural identity, while fostering their overall development. The State General Administration of Sport and the State Ethnic Affairs Commission (2018) emphasize that ethnic traditional sports play an important role in cultural education and social development, but further improvements are needed in teaching content, formats, and resources. Teachers recognize the importance of integrating ethnic traditional sports into physical education classes, but face challenges in practice. In the future, we need to promote the popularization and development of ethnic traditional sports in rural primary schools through curriculum development, teacher training, activity organization, campus culture building, and home- school-community cooperation. This will help address potential challenges in implementation and achieve a deep integration of ethnic traditional sports with rural primary school physical education.

5. The Pathways for Integrating Ethnic Traditional Sports into Rural Primary Schools

Based on the content of Figures 12 and 13, the word clouds provide richer insights and suggestions for integrating ethnic traditional sports into rural elementary schools. To effectively promote the popularization and development of ethnic traditional sports in rural primary schools, a series of strategies should be adopted. These strategies not only help enrich the content of rural elementary school physical education curricula, but also enhance students' sense of national pride and cultural

identity, while promoting their overall development.

(1) Curriculum System and Instructional Design

Incorporating ethnic traditional sports into the school-based curriculum system is essential. This ensures that these activities become a regular part of students' daily learning and helps design course content tailored to the characteristics of students at different grade levels, thereby improving the systematic and coherent nature of teaching. For example, lower-grade students can learn simple skills such as throwing embroidered balls, while upper-grade students can participate in more challenging activities like plank shoe racing. This tiered approach to teaching better meets the needs of students of different ages and stimulates their interest in learning（Wei,2025）.

(2)Teacher Training and Professional Development

Provide specialized training for physical education teachers and invite experts or inheritors of ethnic traditional sports to schools for guidance, in order to enhance teachers' professional abilities. At the same time, encourage teachers to participate in relevant academic exchanges and training activities, which helps broaden their horizons and improve their teaching standards. Through these measures, it can be ensured that teachers possess sufficient knowledge and skills to effectively teach ethnic traditional sports programs（Zheng,2025）.

(3) Activity Organization and Campus Culture Building

Regularly organizing ethnic traditional sports activities, such as school sports meets and class competitions, is an effective way to stimulate students' enthusiasm for participation. These activities not only showcase the charm of ethnic traditional sports but also strengthen students' teamwork and sense of competition. In addition, conducting inter-school exchange activities to promote learning and communication between different schools is also very important. Through these activities, students can better understand and experience ethnic traditional sports, enhancing their sense of cultural identity（Zhang,2025）.

In terms of campus culture building, platforms such as campus bulletin boards and broadcasting can be used to promote ethnic traditional sports culture and create a strong cultural atmosphere. Building a cultural corridor for ethnic traditional sports to display their historical origins and cultural connotations allows students to be subtly influenced by the culture. Through these measures, students' interest in and recognition of ethnic traditional sports can be enhanced.

(4) Home-School-Community Collaboration and Resource Integration

Encourage parents to participate in ethnic traditional sports activities, using parent-child interaction to deepen students' understanding of ethnic culture. At the same time, cooperate with local communities to utilize community resources for organizing ethnic traditional sports activities, forming a good pattern of collaborative education among families, schools, and communities. This collaborative model not only enriches students' extracurricular activities but also strengthens family and community support and participation in ethnic traditional sports.

During implementation, some challenges may arise, such as insufficient teaching staff, inadequate facilities and venues, and lack of student interest. To address these issues, several countermeasures can be adopted. For example, strengthen teacher training and introduce professional talent to solve the shortage of teaching staff, use remote education platforms to bring in high-quality external teaching resources, and seek government and social support to improve sports facilities. For the issue of insufficient student interest, diverse teaching methods and activity formats can be used, combined with modern technology such as video teaching and virtual experiences, to stimulate students' enthusiasm.

Specific Projects and Activity Implementation Diversified Sports Programs: Based on the word cloud, design specific activities suitable for rural primary schools by incorporating projects such as "martial arts," "stilt walking," "bamboo pole dance," and "jump rope," as well as suggested activities like "dragon boat racing," "wrestling," and "archery."

Emphasis on Both Culture and Skills: While teaching sports skills, also educate students about the relevant cultural backgrounds—for example, the cultural significance of "mountain songs" and "dragon and lion dances"—to enhance students' sense of cultural identity.

Balancing Safety and Fun: Ensure all activities are conducted in a safe environment, while increasing their appeal through gamification and storytelling. For instance, combine the "musical chairs" game with ethnic stories to make activities more engaging.

6. Conclusion

The integration of ethnic traditional sports into rural primary schools in Guangxi holds significant importance. It not only enriches the curriculum and increases students' interest in participation, but also cultivates students' sense of national pride and cultural identity. By passing on ethnic culture through sports activities, it is possible to effectively protect and promote Guangxi's rich ethnic cultural heritage. Future research can further focus on the teaching effectiveness of different ethnic traditional sports programs and explore how to better combine modern educational technology to enhance teaching quality.

Although we have discussed various factors influencing students' interest in participating in ethnic traditional sports activities, the independence of interest itself still warrants further analysis in future research. Independent factors such as individual personality and family background may affect students' interests, yet these are often difficult to capture in quantitative studies. Therefore, future research could adopt qualitative methods, such as in-depth interviews and case studies, to gain a deeper understanding of how these independent factors shape students' interests. In addition, designing long-term follow-up studies to observe changes in students' interests and their relationship with participation can reveal the dynamic link between interest and participation.

The issue of poor teamwork is equally complex, with generally weak correlations to other variables, suggesting it may be the result of multiple influencing factors. To gain a more comprehensive understanding of this issue, future research could employ mixed-methods approaches, combining quantitative data analysis with qualitative interviews to uncover the complex reasons behind poor teamwork. Besides obvious factors such as equipment, venues, and guidance, it is also worth exploring other potential factors like students' personality differences, team dynamics, and social skills, which may be more fully reflected in qualitative analyses.

Moreover, designing and implementing intervention programs — such as team-building activities and communication skills training— to improve students' teamwork abilities is also a valuable research direction. By evaluating the effectiveness of these interventions in reducing poor teamwork and increasing participation, practical guidance can be provided. At the same time, conducting cross-cultural comparative studies to explore differences in students' interest and participation in ethnic traditional sports under different cultural backgrounds, as well as the influencing factors, can offer a broader perspective for understanding and promoting ethnic traditional sports.

Finally, investigating how students' interest and participation in ethnic traditional sports affect their long-term outcomes—such as physical health, social skills, and cultural identity—is also an important direction for future research. These findings can not only contribute to the existing literature but also provide guidance for policy-making and practice, promoting the integration and development of ethnic traditional sports in education. Through such comprehensive research, we can gain a more complete understanding of the factors influencing students' participation in ethnic traditional sports activities and provide effective strategies to enhance their engagement and interest.

A deeper understanding of students' awareness, participation, and interest in ethnic traditional sports, as well as the practical problems and challenges faced by teachers in teaching these sports (Wei, 2025), forms the basis for proposing targeted recommendations and strategies. This aims to enrich the content of physical education in rural primary schools and promote students' all-round development, while also exploring new approaches and methods for the inheritance and development of ethnic traditional sports (Guo, 2025). The research is not only of theoretical significance, enriching the theoretical system of integrating ethnic traditional sports with school physical education (Liu, 2025), but also of practical value, providing concrete guidance and reference for the reform and development of physical education in rural primary schools, promoting the widespread dissemination and in-depth practice of ethnic traditional sports, and supporting the revitalization of rural education and the inheritance of ethnic culture (Wei,2025).

Author Biographies

Yan Qiuyi

Yan Qiuyi is a researcher at Guilin Medical University in Guangxi, China, and the first author of this paper. Focusing on integrating ethnic traditional sports with modern education, Yan explores innovative teaching methods to embed rich ethnic sports culture into primary and secondary school

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Huang Yuxi

Huang Yuxi, the corresponding author, serves as the principal of Minquan Primary School in Genzhu Town, Guigang, Guangxi. Huang possesses extensive experience in promoting ethnic traditional sports education. By introducing local ethnic sports like bamboo pole dancing and embroidered ball throwing and organizing relevant activities, Huang aims to spark students' interest in ethnic culture. Huang's teaching philosophy focuses on fostering students' overall development through sports, particularly their teamwork and ethnic cultural heritage awareness.

Qin Gangjian

Qin Gangjian is the principal ofFen Shui Primary School in Genzhu Town, Guigang, Guangxi. Qin actively engages in teaching ethnic traditional sports, exploring suitable models for rural primary schools. Qin emphasizes cultivating students' interest and participation in ethnic sports and integrating local resources into PE courses to enrich rural sports education.

Yan Subo

Yan Subo is the deputy head of academic affairs at No.2 Junior High School in Gangbei District, Guigang, Guangxi. Yan focuses on promoting ethnic traditional sports education, particularly curriculum development and teaching - effectiveness evaluation in junior high schools. Yan strives to enhance students' understanding and participation in ethnic traditional sports through better teaching design and activities, while promoting the inheritance of ethnic sports culture among young people.

Xie Dongmei

Xie Dongmei is a teacher at Central Primary School in Genzhu Town, Guigang, Guangxi. Specializing in elementary education with a focus on ethnic traditional sports, Xie actively participates in school - based curriculum design and teaching. Xie is dedicated to creating more opportunities for students to engage with ethnic traditional sports and cultivating their enthusiasm for these activities to preserve local ethnic sports culture.

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Figure 1 Correlation Heatmap of Interest and Influencing Factors

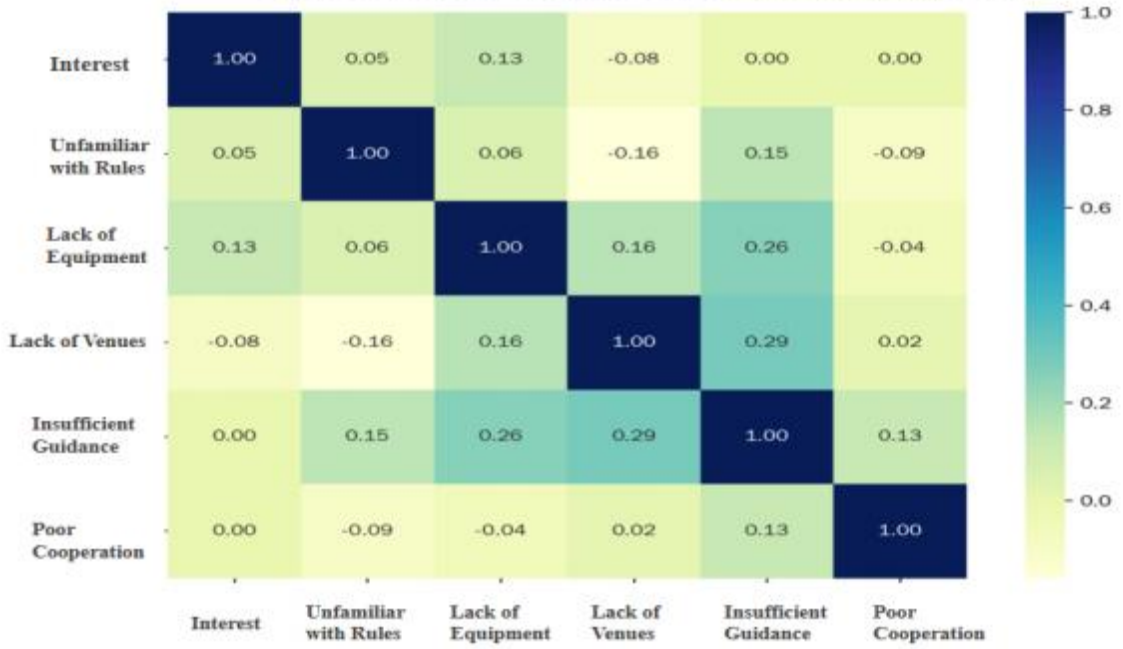

Table1 Correlation Matrix Between Interest and Influencing Factors

Interest	Unfamiliar with Rules	Lack of Equipment	Lack Of Venues	Insufficient Guidance	Poor Cooperation
1.0000	0.0527	0.1273	-0.0841	0.0032	0.0004
0.0527	1.0000	0.0569	-0.1588	0.1521	-0.0926
0.1273	0.0569	1.0000	0.1649	0.2608	-0.0423
-0.0841	-0.1588	0.1649	1.0000	0.2913	0.0159
0.0032	0.1521	0.2608	0.2913	1.0000	0.1303
0.0004	-0.0926	-0.0423	0.0159	0.1303	1.0000

Figure 2 Cross-Analysis of Interest and Participation Frequency in Ethnic Traditional Sports Activities

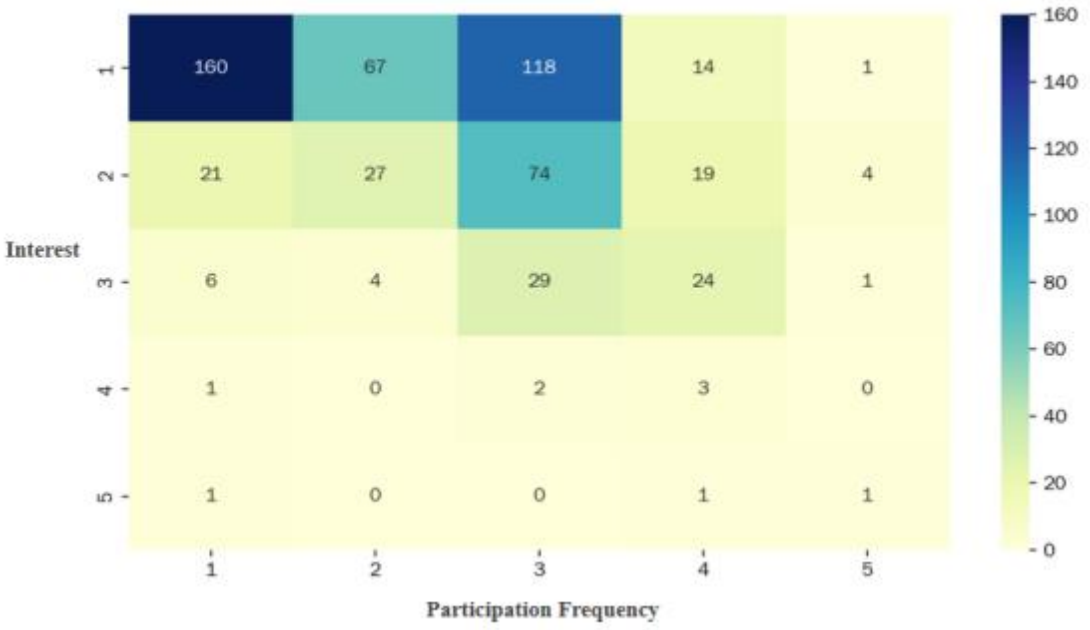

Figure 3 Main Obstacles Students Encounter When Participating in Ethnic Traditional Sports

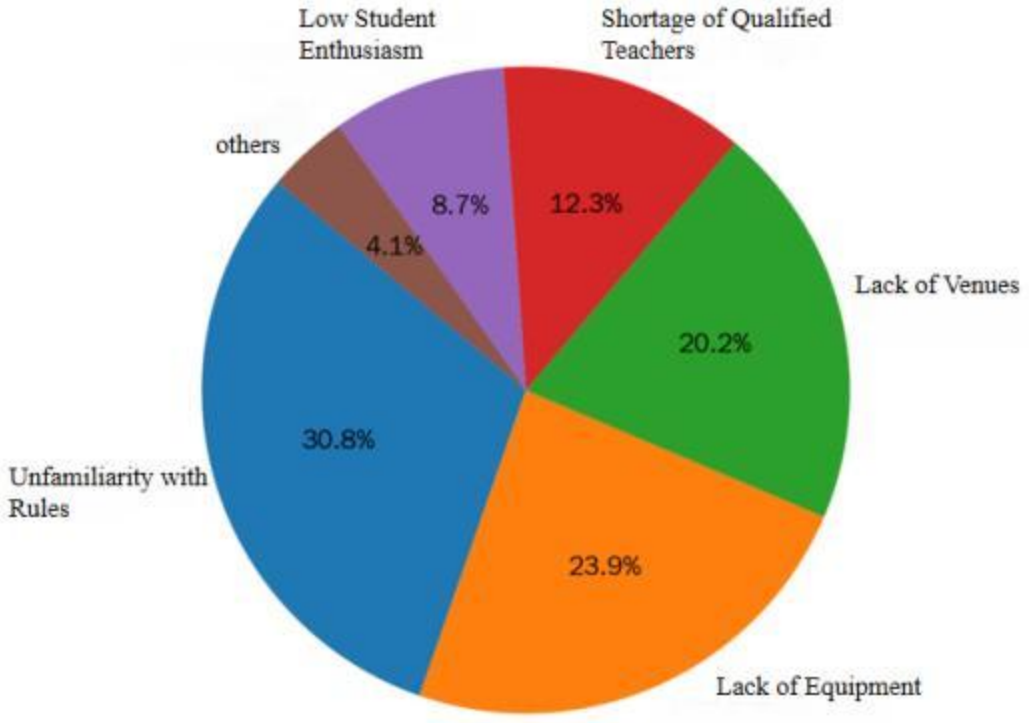

Table2 Distribution of Interest and Participation Frequency in Ethnic Traditional Sports Among Students of Different Grades and Genders

Grade	Gender	Very Interesting	Compare interesting	Commonly	Not very interesting	Not interested in	Daily Participation	3-4 times per week	1-2 times per week	Almost never attended	Never participated
Grade 3	Boy	69.39	22.45	6.12	0	2.04	41.84	13.27	30.61	11.22	3.06
Grade 3	Girl	62.64	21.98	13.19	2.20	0	35.16	12.09	38.46	14.29	0
Grade 4	Boy	56.36	27.27	14.55	0	1.82	16.36	23.64	29.09	25.45	5.45
Grade 4	Girl	58.00	34.00	8.00	0	0	20.00	22.00	40.00	18.00	0
Grade 5	Boy	47.44	32.05	17.95	2.56	0	17.95	32.05	40.00	3.08	6.92
Grade 5	Girl	36.92	20.00	40.00	3.08	0	36.92	20.00	40.00	3.08	0
Grade 6	Boy	38.03	32.39	25.35	4.23	0	12.68	25.35	47.89	14.08	0
Grade 6	Girl	32.39	29.58	32.39	5.63	0	15.49	29.58	43.66	11.27	0

Figure 4: **Chart on Different Grades and Genders of Students' Interest in National Traditional Sports Events and Participation Frequency**

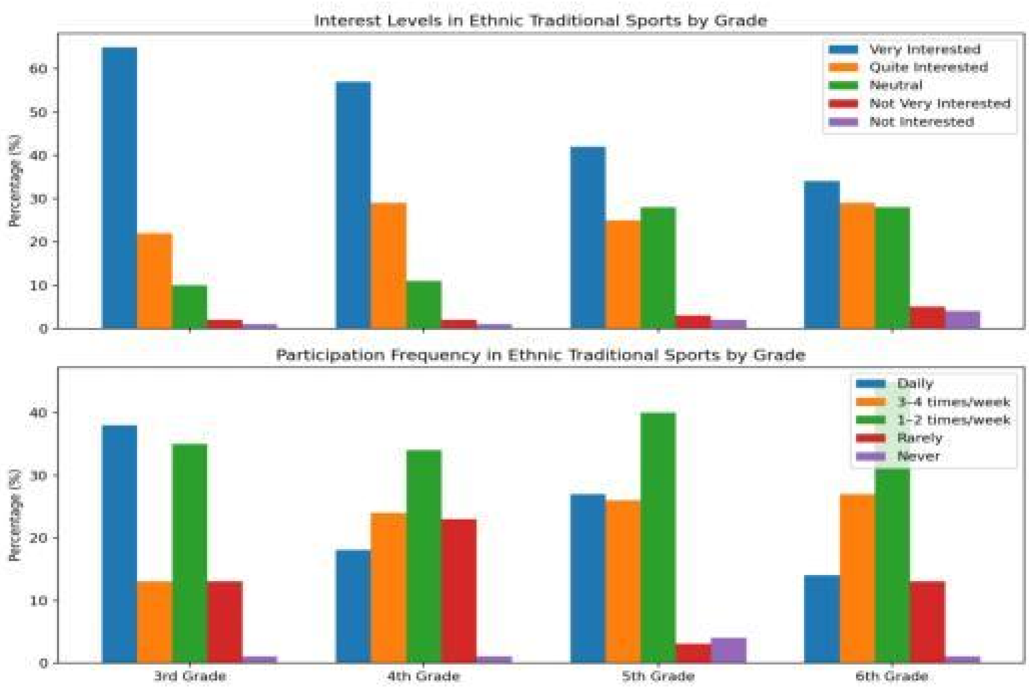

Figure 5

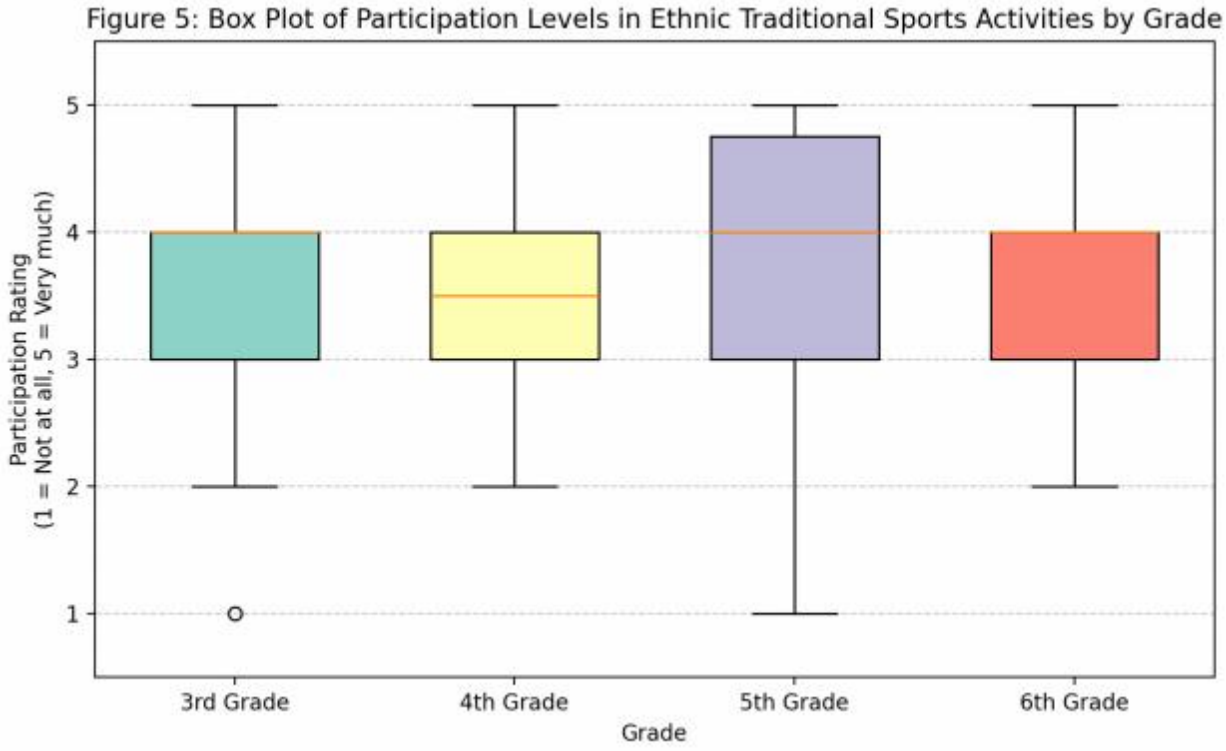

Table 3 Average Scores by Grade on Educational Dimensions of Ethnic Traditional Sports Activities

Grade	Cultural Storytelling	Traditional Music Coordination	Team Cooperation Awareness	Physical Coordination Ability	Competition Awareness
1	0.7143	0.5820	0.7354	0.6561	0.3386
2	0.7810	0.7048	0.7524	0.6571	0.3143
3	0.8462	0.6434	0.8182	0.7552	0.4825
4	0.7234	0.5390	0.7872	0.6383	0.3262

Figure 6

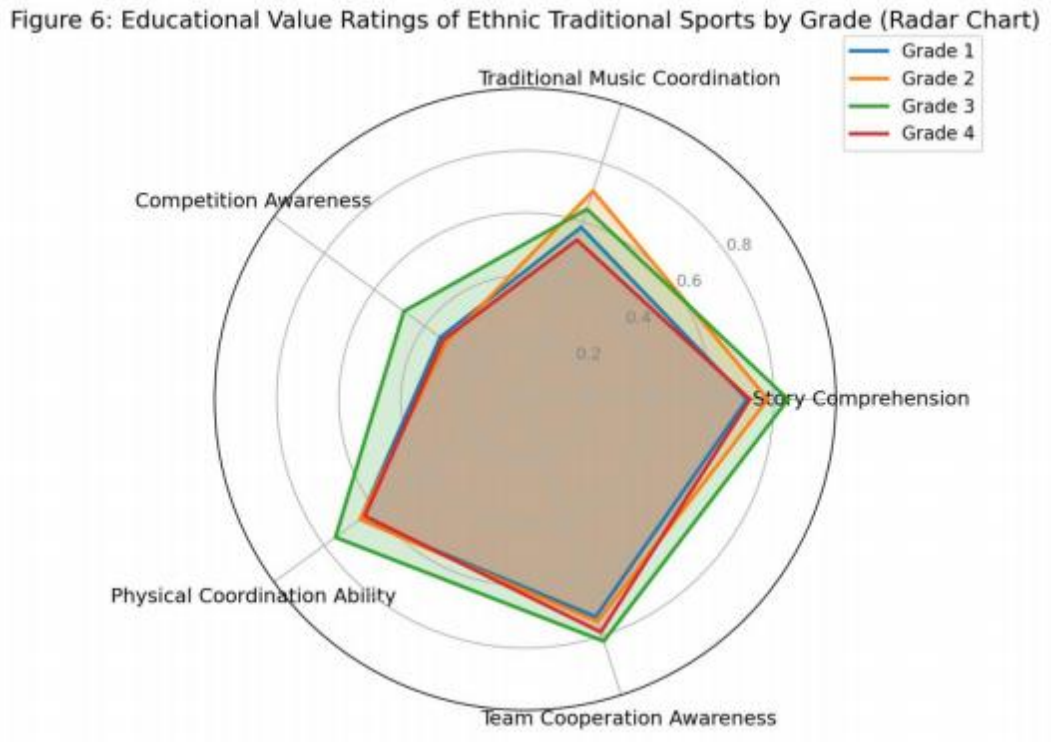

Figure 7

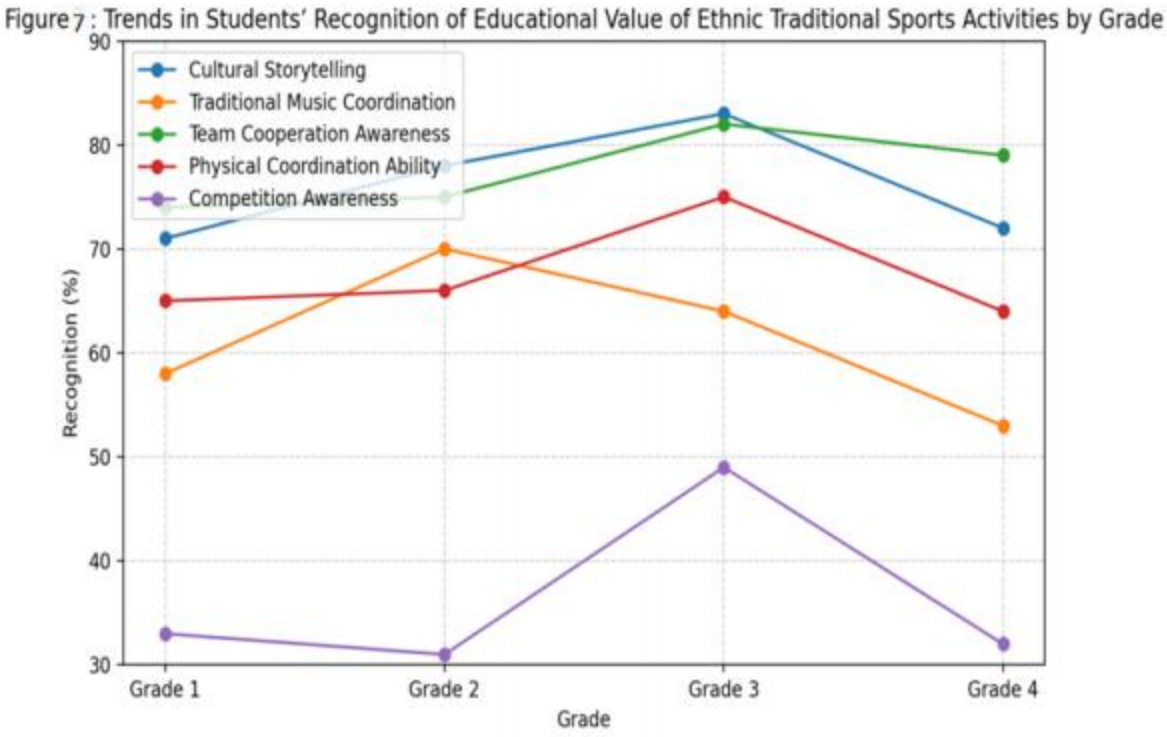

Table 4: Mean Scores of Major Influencing Factors and Educational Value Recognition Among Students of Different Grades

19(Cultural Storytelling)	19(Traditional Music Coordination)	10(Team Cooperation Awareness)	10(Physical Coordination Ability)	10(Competition Awareness)
71.4286	58.2011	73.5450	65.6085	33.8624
78.0952	70.4762	75.2381	65.7143	31.4286
84.6154	64.3357	81.8182	75.5245	48.2517
72.3404	53.9007	78.7234	63.8298	32.6241

Figure 8

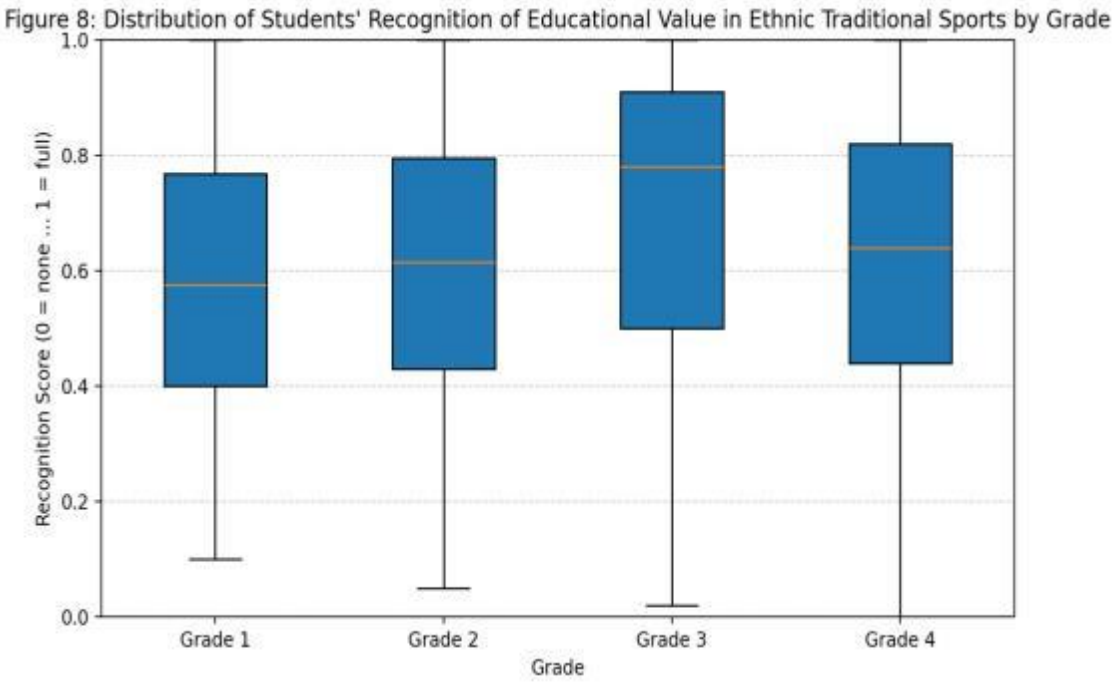

Table5: Descriptive Statistics of Students' Recognition of the Educational Value of Ethnic Traditional Sports Activities by Grade

Walking on stilts while coordinating with (Traditional accompaniment looks like this:	When participating in ethnic traditional sports activities, which of the following difficulties have you encountered? (multiple choice):15 (Do not understand the activity rules)	15 (Lack necessary equipment)	15 (Not enough venue space)	18 (Poor coordination among classmates)	18 (Need to provide more equipment)	19 (Need to improve activity venues)	19 music accompaniment)
1.7407	0.5079	0.4021	0.3545	0.5714	0.5079	0.3545	0.5820
1.7810	0.5524	0.4	0.2	0.6286	0.5619	0.3143	0.7048
1.6713	0.4406	0.2797	0.4336	0.6364	0.4615	0.4685	0.6434
1.6809	0.5887	0.5319	0.3404	0.5816	0.6241	0.3688	0.5390

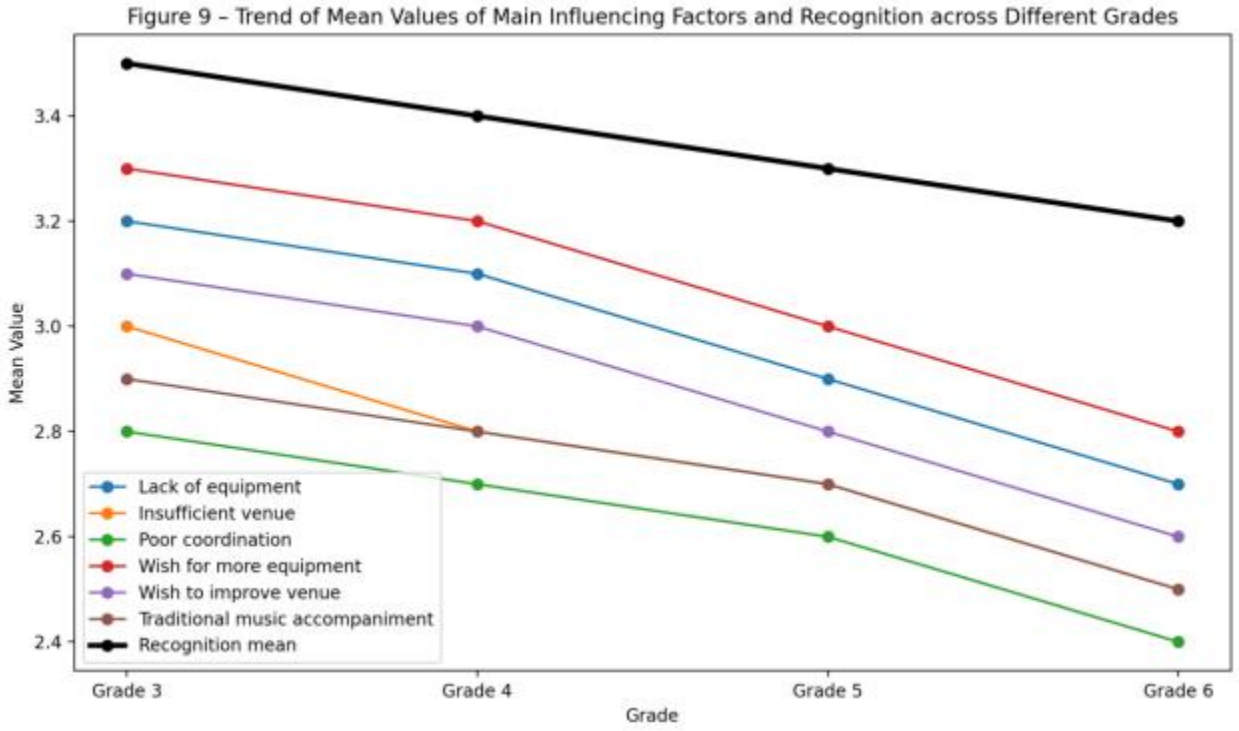

Table 6 Mean Values of Major Influencing Factors and of Recognition across Different Grades

nt	Lack of equipme	Insufficie n t venues	Insufficie n t venues	Desire for more equipme nt	Desire to improv e venues	Traditional music accompanime nt	Mean recogniti on score
	1.7407	0.507 9	0.402 1	0.3545	0.571 4	0.5079	0.3545
	1.7810	0.552 4	0.4	0.2	0.628 6	0.5619	0.3143
	1.6713	0.440 6	0.279 7	0.4336	0.636 4	0.4615	0.4685
	1.6809	0.588 7	0.531 9	0.3404	0.581 7	0.6241	0.3688

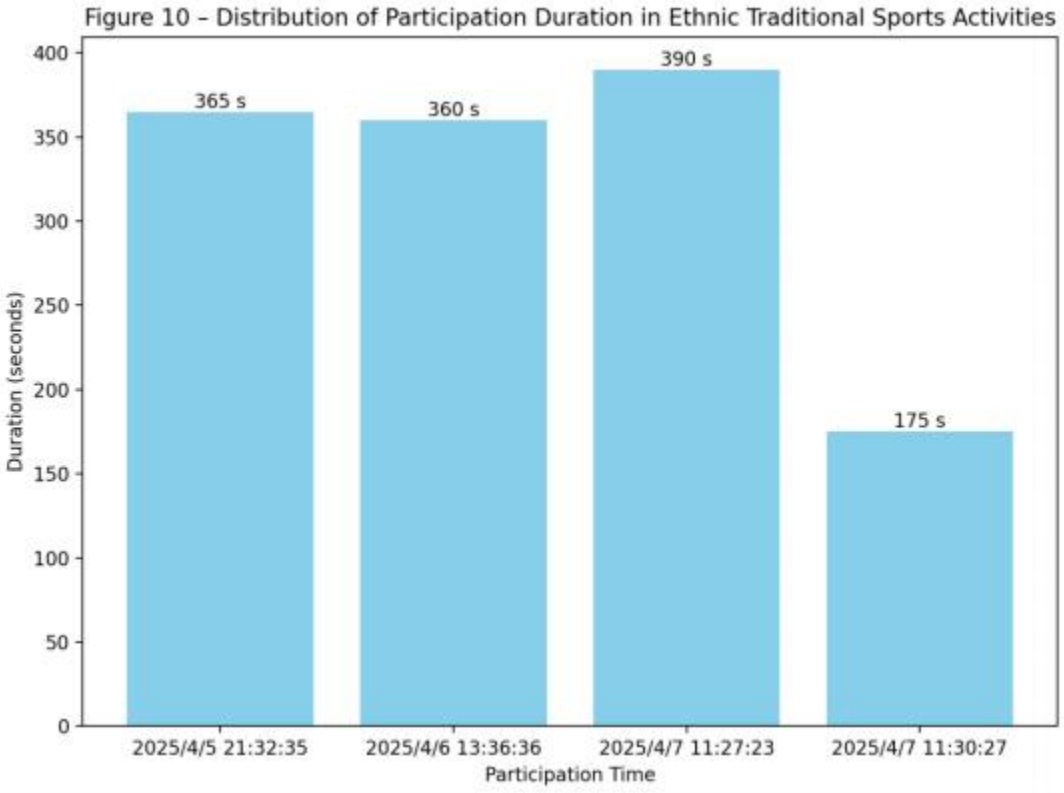

Figure11 Analysis of Participation and Satisfaction in Ethnic Traditional Sports Activities

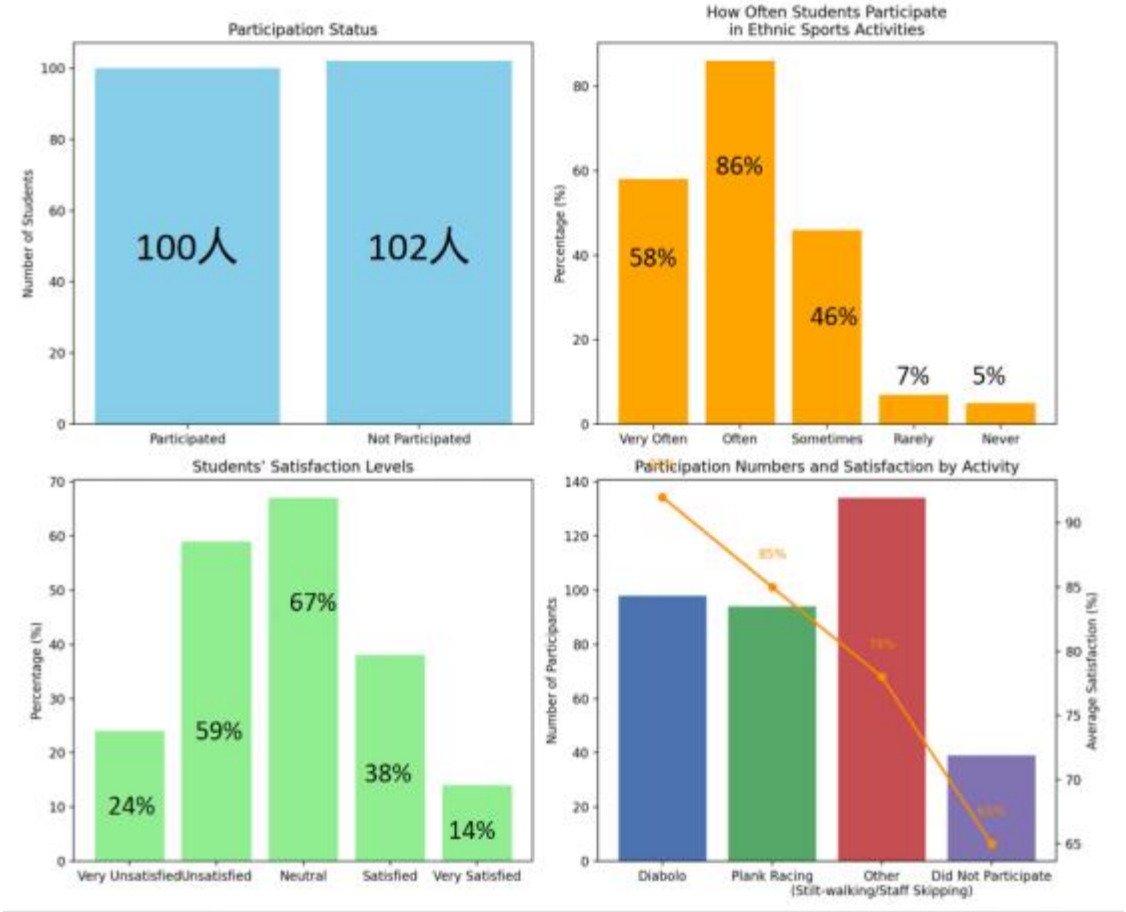

Figure 12 Word Cloud (What other suggestions or opinions do you have on integrating ethnic traditional sports into rural classroom instruction?)

Figure 13: Word Cloud (Which other ethnic traditional sports do you think are suitable for integration into rural physical education classes?)

Information Reformulation Strategies in Simultaneous Interpreting

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Abstract: Though simultaneous interpreting did not start its public use at a large scale until the Nuremberg trials after World War II, it has been widely used in international conferences due to its high efficiency. In China, more and more undergraduate students come into contact with simultaneous interpreting. This study, based on Gile's Effort Model (2009), tries to understand how some undergraduate students were using information reformulation strategies in interpreting practices. It is hoped to provide some ideas to help improve undergraduate students' simultaneous interpretation abilities.

Keywords: Simultaneous interpreting; the Effort Model; information reformulation strategies

1. Introduction

Interpreting, a way to improve communication between people in different languages, has thousands of years in history. However, simultaneous interpreting, with its first large-scale public appearance at the Nuremberg trials after World War II, has a relatively shorter history. (Flerov, 2013; Porzucki, 2014). Today simultaneous interpretation has become extremely popular and has been largely used in many international conferences due to its high efficiency.

The pressing demand for a qualified simultaneous interpreter has led to the belief that such a profession is among those talented interpreters with high language proficiency, extremely good memory, a big heart, and a strong mind. Therefore, in China, for a long time, the study and training of simultaneous interpreting is a course only available for postgraduate students. In recent years, the ever-increasing proficiency of Chinese students has stimulated the trials of offering simultaneous interpreting courses to undergraduates. Such a radical change has brought both support and doubts in the study and teaching of simultaneous interpreting. As more and more undergraduate students are engaged in simultaneous interpreting learning, it is necessary to give more studies to undergraduates in their simultaneous interpretation (SI) learning.

Simultaneous interpreting (SI) generally occurs in enclosed interpreting booths where two up to four interpreters reformulate the delivered speech from one source language into another target language to help the audience of the target language understand the messages at the same time.

In simultaneous interpreting activities, ideally, interpreters expect and are expected by the audience to provide coherent interpreting production remaining to source content as much as possible, yet some common difficulties, for example, fatigue, lack of comprehension of some specific terms, and the structural differences between the source language and target language may hinder the performance of the interpreters in the interpreting process. To overcome such difficulties, interpreters will employ reformulation strategies of different kinds, such as generalization, omission, and explanation, from which student interpreters can learn to improve their abilities in SI (Gile, 2009).

This paper tries to explore the employment of reformulation strategies by undergraduates of translation major in a Chinese university when they were having interpreting practice.

2. Literature Review

An extensive range of reading on CNKI, using ‘simultaneous interpreting’ as a key phrase to search, has revealed the changes in studies in this area: from the Interpretive Theory (Liu, 2001; Bao, 2005) to Prediction with Schema Theory, and to Reformulation Strategies from problem triggers (Gile, 2009; Xu, 2020; Jiang, 2021). The research studies of reformulation strategies, based on Gile’s Effort Model,

center on such problem triggers as fast speeches with dense information, names and terms, and speech with loose logic. Therefore, following the research pattern on reformulation strategies, this paper attempts to look at reformulation strategies from professional and student interpreters by resorting to Gile's Effort Model.

Though simultaneous interpreting is a late starter in the history of translation and interpreting, studies on simultaneous interpreting never lack attention (Liu, 2001； Bao, 1998; Gile, 2009). Among the studies, information reformulation strategies have always been given special concern (Gile, 2009; Chernov, 2004; Han & Chen, 2016).

According to the Effort Model (Gile 2009:159), "interpreting requires some sort of 'mental energy' that is only available in limited supply. Interpreting takes up almost all of this mental energy, and sometimes requires more than is available, at which times performance deteriorates."

The formula proposed by Gile, SI=L+P+M+C, indicates interpreting involves a lot of non-automatic operations, such as listening and analysis, remembering and production of the messages within a short-term memory span, and the efforts to coordinate the non- automatic operations.

In this formula, SI stands for the whole interpreting process, which consists of those elements as the Listening and Analysis Effort "L", the Short-term Memory Effort M, the Speech Production Effort P, and the Coordination Effort C.

According to Gile (2009: 160), in listening and analysis, except for some names that interpreters can imitate phonetically, there is no one-to-one relation between the sound entering into the ears of the interpreters and any single word or groups of words pronounced by the speakers. Besides, in the interpreting process, difficulties brought by speakers' speech planning may add more pressure to interpreters' effort management.

Gile (2009) considers short-term memory important in that interpreters need time to analyze phonetic segments with later information provided by the speakers, as well as in choosing the appropriate words for the production. In the interpreting process, when interpreters encounter speeches with poor logic, dense information, and unfamiliar accent, they usually prefer to wait sometime than straightly deliver the fragmented sentences to the audience in hopes to store the information for later use so that they can catch the central meaning of the message. So, Memory Effort is important in interpreting. Also, the language differences between the source and target language demand extra memory workload.

Gile (2009) asserted that no matter how well an interpreter is prepared and how extensively s/he is experienced, there are cases where s/he does not understand a term or a sentence in the source text, or s/he doesn't know an appropriate term to express a concept in the target language. Even though the interpreter is knowledgeable and informative in one specific interpreting practice, he may still come to cognitive saturation and fail because speeches are "too fast" or "too dense". In other words, if the source speech is delivered at a high rate, if there is a high density of the information contained in the speech, or if the speech has included unknown names and gives the interpreter a low chance of anticipation, the interpreter will choose to omit to translate some content so that he will not get more pressure and make more mistakes.

Gile (2009) has provided tactics for simultaneous interpreting in three aspects: comprehension tactics, preventive tactics, and reformulation tactics. As reformulation tactics are most useful to handle problem triggers (such as fast speeches with dense information, names and terms, and speech with loose logic), reformulation tactics/strategies are given more consideration.

3. Research Methodology

This section discusses the research process, including the participants in the experiment, the material used in the experiment, tools to transcribe the recordings of the participants, and the procedures ofthe experiment.

3.1 Participants

The participants in this study are senior students from the Pilot Program of Multilingual Translation of Chinese, English, and French from a Chinese university. As student interpreters, Chinese was their native and source language and English their target language, and all of them had undergone undergraduate English - Chinese simultaneous interpreting learning for one semester and a half.

3.2 Material

The material used in the experiment was excerpted from a special session of a press briefing on "the Celebration of the 100th Anniversary of the Founding of the Communist Party of China". The theme of the session, the 100th anniversary of the

Communist Party of China, has been frequently used in consecutive interpreting and political translation courses. Thus, they have acquired some general vocabulary for their interpreting performance in this experiment. However, to alleviate the workload for the participants, some special terms were still provided beforehand.

The source text consists of three sections. The lead-in part introduces the purposes of the interview, which is followed by the host introducing the interviewees. The final section of the source text is the story of Zhao Pubo, the first interviewee and the chief welder at China's nineteenth metallurgical corporation.

The source text featured high speech density with dense information at a high rate of delivery. For example, the interviewee, Mr. Zhao, spoke with a heavy accent at an average rate of 260 words per minute, even faster than the host, who spoke at the rate of 210 words per minute.

3.3 Experiment Tools and Procedures

Experiment tools used in this experiment include headphones, recording devices in the SI classroom, pen, paper, software for later audio transcription, etc.

There are seven steps in the experimental procedures. Before taking the experiment, the original material was downloaded from the Internet. As the material was around 20 minutes long, the beginning part of the material (about 3 minutes and 40 seconds in length) was excerpted for the experiment. Secondly, the participants were informed of the time and the place, and each of them acknowledged that their performance would be recorded and analyzed for the experiment. Thirdly, the equipment of the experiment, such as headphones, microphones, and recording devices, were checked for proper operation. After all the preliminary work was done, scaffolding work was given to provide some special terms and background information in order to alleviate the workload of these participants and student interpreters. The participants then started interpreting when hearing the word "女士们". After the interpreting work was over, the recordings of all the participants were collected through the classroom 's recording software.

3.4. Corpus Analysis

With the help of Voicenote, a mobile phone app to transcribe the audio recordings, all the recordings, including the transcripts ofthe excerpted audio material for the experiment and of the professional interpreter for the press briefing, were transformed into written texts for further analysis. All transcriptions were checked by the author to exclude the inaccuracy made by the software.

4. Results and Discussion

This section attempts to have a closer look at the reformulation strategies used by the five participants in three aspects, namely reformulation strategies for fast delivery plus dense information, reformulation strategies for proper nouns and technical terms, and reformulation strategies for loose-logic information.

The study has chosen several examples from the source text. A table is given for each example. In each table, the participants' interpreting work was analyzed with the transcripts of the professional interpreter to understand reformulation strategies used by student students in simultaneous interpreting and to discover the differences between the professional interpreters and student interpreters in using the reformulation strategies.

In the analysis, the professional interpreter is named as P; the Participants are A, B, C, D, E. The reformulation strategies used in the analysis include: 1) replacing a segment with a superordinate term or a more general speech segment (simplified as 'generalization' in the following analysis); 2) explaining or paraphrasing;

3) reproducing the sound heard in the source-language speech; 4) transcoding;5) form-based interpreting; 6) omitting. Examples below include a source text segment and the corresponding interpreting transcripts from the participants.

4.1. Reformulation Strategies for Fast Delivery plus Dense Information

Through two examples, the author of this paper has found that when listening to and trying to process dense information at fast-paced delivery, the students, lacking in experience, tried to remember as much source information as possible, especially minor information, while a professional interpreter gripped the key information.

Example 1

ST:16 岁那年出于对(1)焊花的(2)好奇和(3)憧憬，我选择了(4)焊接这个(5)专业。第一次穿上厚厚的(6)防护服，戴上炫酷的(7)防护面罩， 同时也感受到了 焊接这项工作有着常人难以想象的(8)艰辛。

The dense information comes from the nouns underlined in the source text as (1)焊 花(welding sparkles);(2)好奇(curiosity);(3)憧憬(aspiration); 4)焊接(welding);(5)专 业(career)；(6)防 护 服(protective gear); (7) 防 护 面 罩 (protective mask)(8) 艰 辛

(hardship). How are these nouns handled by different interpreters?

The different interpretation versions are shown in Table 1 (See Appendix 1). In the table, the nouns covered are underlined, and added with numbers of nouns in the source text in the brackets.

A comparison of the professional interpreters and the five students has shown that the professional interpreter, aware more of the differences between the two languages, has made a much simpler sentence with three omissions. However, four participants attempted to cover as many underlined nouns as possible.Therefore, it seems that those participants have paid extra effort to production effort compared with the professional interpreter.

On the other hand, while not knowing the English equivalent of "防护服"(protective gear), the participants, as student interpreters, have used several superordinate words to replace it, such as the equipment, clothing, clothes, and suit. In this case, the production effort is saved, yet the accuracy of information is lost to some extent.

Example 2

ST: 在庆祝(1)中国共产党成立(2)一百周年之际，(3)党中央决定为(4)党龄 50 年以上、(5)一贯表现良好的党员颁授(6) "光荣在党 50 年"纪念章，(7)710 多万(8)老党员获此殊荣。

In this sentence, the underlined parts have indicated dense and difficult information as in proper nouns, some phrases, and numbers. The underlined parts are labeled with numbers to see how interpreters were dealing with them. These words stand for: (1) CPC;

(2) centenary; (3) CPC Central Committee; (4) over 50 years of membership; (5) fine performance; (6) 50-year glory medal; (7) over 7.1 million (8) old party members.

The different interpretation versions are shown in Table 2 (See Appendix 2).

The professional interpreter has reformulated the source text by changing the order of the source text. The well-constructed information in the target language is displayed with the addition of some unrelated information as "This is the first time in the party history and showcases the central committee's care for old party members and high recognition of their historic contribution. " As the interpreter did not finish "710 多万" in English, a rough guess from the author of this paper can be that the interpreter was stuck with the number and came up with "parallel information."

The participants' versions, on the other hand, are vastly different from the professional interpreter in that the information has been oversimplified with most of the proper nouns omitted. Besides, some proper nouns were replaced with superordinate words, and the number "710 多万" was mostly mistranslated. The poor performance of these participants as student interpreters has illustrated that they are not familiar with the proper nouns and technical terms, so they saved their production effort with reformulation strategies at the expense of the quality of the interpreting work.

4.2 Reformulation Strategies for Proper Nouns and Technical Terms

Proper nouns and technical terms are time-consuming and energy-demanding when the student interpreters were producing the language output with their short-term memory. Studies on the interpreters' version have revealed that most of them have adopted the strategy of omission more frequently than other reformulation strategies.

Example 3

ST: 首先请允许我逐一介绍一下他们，他们是：中国(1)十九冶集团有限公司(2)首席(3)焊工技师赵脯菠先生；(4)中国科学院院士、清华大学(5)生命科学学院教授隋森芳先生；(6)全国人大常委会办公厅(7)离退休干部局(8)第十一党支部书记刘金华女士；(9)湖南省(10)常德市(11)桃源县(12)茶庵铺镇个体货车司机龙兵先生。

The different interpretation versions are shown in Table 3 (See Appendix 3).

Example 3 contained proper nouns of titles, careers, and places. As the participants cannot find an appropriate equivalent of "中国科学院院士", three of them omitted the translation of the title. Even though Participant A managed a correct name for the institution "中国科学院", he used the superordinate word "scholar " to represent the Chinese proper title of "院士"。Seemingly the translation of the place "湖南省常德市桃源县茶庵铺镇" can be done through the strategy of reproducing the sound heard in the source-language speech, most participants failed as they could not catch the complicated pronunciation of "湖南省常德市桃源县茶庵铺镇", the place from which the lorry driver comes, with Listening and analysis Effort.

Example 4

ST: 我的理想是成为一名(1)新时代(2)复合型的(3)高技能人才，为(4) "中国制造"成为(5) "中国精造"贡献自己的力量，继续为党和国家争光。谢谢。

The different interpretation versions are shown in

Table 4 (See Appendix 4). Technical terms are not only those for science and technology. They may also refer to some sociopolitical words, such as "新时代，复合型，中国精造". Unable to find equivalent words in English, the professional interpreter took the omission strategy. Most participants, either omitted those sociopolitical words or explained by paraphrasing, for example, "高技能人才". The term has been translated into "very talented manufacturer", "a talent with multiple techniques", "a technician that has skills", "an integrated talent", or "a multi-skilled worker" in the target speech.

4.3 Reformulation Strategies for Loose-logic Information

In Chinese, four-character phrases are frequently used to add literary charm to the language. However, these unique Chinese phrases are loose in logic, and interpreting them in English is difficult. As professional interpreters are proficient in processing the key out of loose logic information, the interpreted versions tend to be simple and straight -forward.

Example 5

ST: 百年征程(1)波澜壮阔，百年初心(2)历久弥坚。"百年征程" refers to "The 100-year journey" in English; and "百年初心" means "the 100-year aspiration". The different interpretation versions are shown in Table 5.

In this Chinese sentence, we can see a parallel SV structure with "百年征程" and "百年初心" as subjects while "波澜壮阔" and "历久弥坚" serve as verbs. However, the participants cannot figure out the meaning of "波澜壮阔" and"历久弥坚" in Chinese, let alone find equivalent expressions in English. Therefore, in reducing the Production Effort, they all skipped the former part of the parallel structure, focusing on the latter part.

In comparison, the professional interpreter gripped the essence of "波澜壮阔", a single word of "extraordinary" is simple and straight -forward.

For the latter part of the example, "历久弥坚", the participants have translated the sense of "历久弥坚" as persistence and endurance. Through omission and translation by sense, the interpreters here reduced the production and short-memory workload, making it easier to continue the interpreting of the subsequent content after this Chinese sentence.

From this example, we can see the student interpreters, though not fluently enough, have attempted to interpret by catching the meaning.

5. Conclusion

Based on the analysis, some findings can be concluded as follows.

First, when encountering dense information at fast- paced delivery, the participants tried to remember as much source information as possible, so they overused their memory availability and affected the quality of the production.

Second, when faced with unfamiliar proper nouns and technical terms, participants were overwhelmed by the Listening and analysis Effort. They either chose superordinate words to summarize or explained some terms by paraphrasing to save their short-term memory load.

Third, in dealing with loose-logic information, for example, some literary four-character expressions like "波澜壮阔", the participants may be at a loss for Chinese meaning and skip over such phrases directly. The effort was saved for the next attempt at interpreting. With knowledge in different areas, a professional interpreter can easily bypass loose logic information by introducing relevant words.

Through the study, it can be seen that the professional interpreter has often used such strategies as omission, summarizing, and translation by sense. Though not fluent, the participants, still student interpreters, have tried some similar strategies such as omission, translation by sense, and generalization. Still, as student interpreters lack experience, they have to learn how to coordinate efforts at listening, remembering, and production.

As Gile proposed (2009), one good way to improve students' simultaneous interpreting proficiency is to provide them with parallel texts so that they can be more familiar with proper names, terms, and sentence structures. Another way is to consolidate students' basic interpreting skills in numbers, and retelling, so that they can shift some of their listening effort and production effort to memory and improve their final delivery. Also, more awareness should be raised to interpret learners on the "laws" of strategy application such as maximizing information recovery and minimizing interference in information recovery.

This study has chosen a small number of participants, so the findings are not able to give a full picture of the students' interpreting proficiency in the pilot program. It cannot even assuredly prove that simultaneous interpreting is accessible to all undergraduates of translation majors. It is hoped that

more work can be done on undergraduate SI teaching and learning so that more interpreters can benefit from the challenging simultaneous interpreting practice.

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Appendix 1: Table 1: Interpretation transcripts

Participants	Interpretation versions
P	When I was 16 years old, I began to learn (4, 5) welding. The first time I put on the (6) protective gear and (7) protective mask, it was kind of cool, but I also experienced extraordinary (8) hardship.
A	When I was 16, out of the interest (2) for welding (1), I chose to become a welder (4, 5). The first time I wore the protective clothing (6) and protective mask (7), I felt it so cool, but it was also a very difficult task (8).
B	I was (2) curious about welding, so I chose this (5) major. At first, I wore the (6) protective clothes and our (7) masks and …
C	Uh when I was 16 years old, I chose the (4,5) welding major because I'm interested (2) in it(1). When I was in the equipment(6,7), I knew that it was a very difficult job（8）.
D	At the age of 16, because I'm curious (2) about welding (1), so I choose welding (3) as my major (4). The first time I put up the protective suit (6), I experienced the hardship (8) of welding.
E	When I was 16, I'm curious (2) about welding objects (1). The first time I wear the helmet (6) and wear the clothes (7), I realize that it's a cool job, but it's hard (8) as well.

Appendix 2: Table 2: Interpretation transcripts

Participants	Interpretation versions
P	On the occasion of the (2) centenary of the (1) CPC, (3) CPC central Committee has decided to award (6)50-year glory medal to party members with (4) over 50 years of membership and (5) fine performance. This is the first time in the party history and showcases the central committee's care for (8) old party members and high recognition of their historic contribution.
A	And the (3) Central Committee has decided to award the (6) medal of glorious to those party members who (4) has been in the party for fifty years. More than (7)7.1 million (8) veteran Party members have received that.
B	During this time, the (3) Central Committee has decided to title Party members (4) above 50 years of membership (6) their medals. More than (7)700 thousand (8) party members have received this medal.
C	(1) The Party has awarded a mem... (6)a medal for the party members that have served the party (4) for more than 50 years.
D	In the time of the (2) centenary, the party (3) decided to give (6) honorable medals to the party members that has joined (4) over fifty years.
E	To celebrate (1)100-year anniversary, (3) the party decided to give (6)a medal for those (5) who have behaved good (4) for more than 50 year long history. (7) More than 700 million people have this medal.

Appendix 3: Table 3: Interpretation transcripts

Participant	Interpretation versions
P	They are, Mr. Zhan Pubo, the (1) chief (2) welder at (3) China nineteenth metallurgical corporation. (4) academician of Chinese Sciences, professor of (5) school of Life and Sciences of Tsinghua University, Mr. Sui Qingfang, secretary of (6) the eleventh party branch of (7) retired officials in general office of (8) the NPC standing Committee, madame Liu Qinghua and self-employed truck driver in (12) Chaoyuan Town, (11) Taoyuan County (10) Changde City (9) Hunan Province Mr. Longbing.
A	The first one is from the (1)19th Metallurgical Group, he is (3)a welder. And the next is, uh, (4) a scholar from China Academy of Science and from Tsinghua University. The third is from (8) the Standing Committee of National Congress. And the last one is from (9) Hunan, he is, uh, a truck driver.
B	They are (1) metallurgic group, the (2) role model of the (3) welding technique worker Zhan Pubo, (4) China's Sciences academician from a Tsinghua (5) school of life and science. And the (6) chief party chief and Chinese driver of the truck.
C	It's the (1)19th unmetallurgical (3)technician Zhao and Qinghua University (5)Life Science Deputy Sui Senfang (6) Standing committee office of the CPC of the National Congress Liu Jinhua (9) Hunan province lorry driver Longbin.
D	From (1) the metallurgical company Mr. Zhao, Professor of Tsinghua University of (4) Life Science and Academy. And the people's (6) congress standing committee. From (9) Hunan province, a trunk driver.
E	They are the the (3) worker of (1) the 19th metallurgical group. A professor from a university (Qinghua's professor. (8) chairman run his, a truck driver from (9) Hunan province.

Appendix 4: Table 4: Interpretation transcripts

Participant	Interpretation versions
P	My dream is to become a (3) high calibre skilled worker and contributed to the (4) made in China and to the cause of the party.
A	And I want (2) to become the (3) very talented manufacturer. And I also want to become an artificer (7) from a manufacturer (6). Thank you.
B	My dream is to be (3)a talent with multiple techniques to contribute to the country and the party. .
C	As (3) a technician that has skills, I hope to uh make glory for the party.
D	My dream (2) is to be a integrated talent (5) in the future and make contribution to the party and my country.
E	And for me, I think I want (2) to be a multi-skilled worker (5), and in the future to win more prizes for the party and the country. Thank you.

Appendix 5: Table 5: Interpretation transcripts

Participant	Interpretation versions
P	The 100-year journey is truly (1) extraordinary and the 100-year original aspiration (2) remains true as ever.
A	Since this one hundred years, CPC (2) has always uphold its original aspirations,
B	We have a (1) splendid Party history and our founding commissions have (2) passed through time.
C	The aspiration of the Party has (2) grown even stronger.
D	The original aspiration of the CPC (2) remain true.
E	It's a (1) hard journey for 100 years. And it is (2) hard to remain an aspiration.

Construction and Application of Smart Emergency Care Model for Geological Disaster Recognition Based on Satellite Remote Sensing

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Abstract: Global climate change and frequent geological disasters pose severe challenges to the safety of lives and property. This paper proposes a smart emergency care model for geological disasters based on satellite remote sensing recognition. The model comprehensively utilizes multi-source remote sensing data, including optical, radar, and thermal infrared data, along with artificial intelligence algorithms, to achieve precise recognition and early warning of geological disasters. Moreover, through an integrated monitoring network, a full-process management system for smart emergency care is established. Field investigations and application validations conducted in geological disaster-prone areas in Guangxi and ASEAN countries demonstrate that the model can significantly improve the accuracy of geological disaster recognition and the response efficiency of emergency care, indicating its valuable potential for widespread application.

Keywords: Satellite Remote Sensing; Geological Disaster Recognition; Smart Emergency Care; Integrated Monitoring; Full-Process Management

1. Introduction

1.1 Research Background

Global climate change has intensified, leading to frequent geological disasters such as earthquakes, landslides, and mudslides, seriously threatening people's lives and property. Statistics show that between 2020-2024, direct economic losses from global geological disasters exceeded $200 billion, with casualties continuing to rise. Satellite remote sensing technology, with its advantages in macro-scale, rapid, and dynamic monitoring, plays a crucial role in geological disaster identification and emergency rescue. Through the integration of multi-source remote sensing data, including optical, radar, and thermal infrared, combined with artificial intelligence algorithms, millimeter-level surface deformation monitoring can be achieved. During major disaster relief efforts, such as the Wenchuan earthquake, remote sensing technology rapidly determined severely affected areas and secondary disaster risks, significantly improving rescue efficiency. With continuous technological advancement, satellite remote sensing-based smart emergency care models, utilizing integrated space-ground monitoring networks, have achieved intelligent management throughout the disaster identification, risk assessment, and emergency rescue process, becoming a new approach to enhance disaster response capabilities.

1.2 Research Purpose and Significance

This study aims to construct a satellite remote sensing-based geological disaster smart emergency care model to address current issues in geological disaster rescue, including delayed information acquisition, inefficient rescue decision-making, and unreasonable allocation of emergency care resources. The study expects to significantly improve disaster emergency response efficiency by establishing an intelligent management platform that integrates disaster identification, risk assessment, rescue decision-making, and emergency care. The research outcomes not only provide new technical means for geological disaster prevention but also promote innovative applications of smart healthcare in disaster rescue, holding profound theoretical value and practical significance.

1.3 Research Content and Methods

This study employs literature review, field research, case analysis, and technical pathway planning methods, focusing on the following aspects:

(1) Specific application mechanisms of

satellite remote sensing technology in geological disaster monitoring

(2) Construction and implementation pathways of smart emergency care models

(3) Integration strategies between satellite remote sensing and smart emergency care systems

(4) Industrial development strategies for Guangxi and ASEAN countries.

2. Technical Principles and Current Applications of Satellite Remote Sensing in Geological Disaster Identification

2.1 Technical Principles

Satellite remote sensing acquires surface imagery and related physical information through various sensors mounted on satellite platforms that receive electromagnetic waves reflected or emitted from the Earth's surface. Based on sensor types and operating wavelengths, satellite remote sensing can be classified into radar remote sensing, optical remote sensing, and thermal infrared remote sensing, each with distinct characteristics in geological disaster identification.

Radar remote sensing utilizes electromagnetic waves in the microwave band, offering advantages such as cloud penetration, weather independence, and the ability to detect minute surface deformations. Synthetic Aperture Radar Interferometry (InSAR) is a crucial application of radar remote sensing in geological disaster identification. Through analyzing phase differences between radar images acquired at different times, it can precisely monitor millimeter-level surface deformations, which is significant for early detection of geological hazards such as earthquakes, landslides, and ground subsidence. (See Figure 2-4).

Synthetic Aperture Radar Interferometry (InSAR) technology represents a significant breakthrough in modern remote sensing. This technology works by using satellite-mounted synthetic aperture radar to transmit microwave signals to the Earth's surface and receive reflected waves, utilizing the satellite platform's motion to synthesize a larger "aperture," thereby obtaining high-resolution surface images. The core of InSAR technology lies in its unique interferometric measurement principle, which acquires radar images of the same area at different times, analyzes their phase difference information, and extracts subtle surface change information. This method can achieve millimeter-level deformation monitoring accuracy, is unaffected by cloud cover and lighting conditions, and can operate around the clock.

In the technical implementation process, InSAR first requires precise registration of acquired radar images, followed by generating interferograms through phase difference calculations. These interference fringes contain surface elevation and deformation information, which can be converted into actual surface displacement or deformation data through phase unwrapping techniques. The entire processing involves complex signal processing and data analysis technologies, requiring consideration of various influencing factors such as atmospheric effects and orbital errors. (See Figure 4)

InSAR technology has extensive applications in Earth sciences. In earthquake disaster monitoring, by comparing radar images before and after earthquakes, it can precisely map surface rupture zone distributions and assess the degree of surface deformation caused by earthquakes. For example, after the 2008 Wenchuan earthquake, InSAR technology helped researchers rapidly obtain surface deformation images of the disaster area, providing crucial evidence for disaster relief decision-making. In urban construction, InSAR is used to monitor ground subsidence. Through long-term data accumulation, it can assess the safety conditions of buildings and infrastructure, preventing geological disasters. (See Figure 5)

In volcano monitoring, InSAR technology can capture subtle deformations of volcanic bodies, which are often important precursor signals of volcanic eruptions. Through continuous monitoring of surface changes in volcanic regions, potential volcanic activity risks can be identified promptly, providing a scientific basis for disaster prevention and mitigation. Additionally, in glacier research, InSAR technology can accurately measure glacier movement speed and melting rates, providing crucial data support for climate change research.

With continuous technological development, the integration of InSAR and artificial intelligence technologies has opened new application prospects. Through deep learning algorithms processing massive radar data, surface deformation characteristics can be identified more quickly and accurately, improving monitoring efficiency and early warning capabilities. Meanwhile, the launch of new-generation radar satellites and the development of multi-source data fusion technologies have further enhanced InSAR technology's monitoring precision and application

scope.

Looking to the future, InSAR technology will play an increasingly important role in natural disaster warning, environmental monitoring, urban planning, and other fields. Through continuous improvement in data processing capabilities, enhancement of monitoring networks, and development of new application models, InSAR technology will make greater contributions to Earth science research and human social development. (See Figure 6)

Optical remote sensing can provide high-resolution images in the visible and near-infrared bands, clearly displaying information such as land cover features, vegetation conditions, and topography. By comparing optical remote sensing images from different periods, changes in the surface before and after geological disasters can be identified—for example, the extent of landslide bodies, the collapse of rock and soil, and the flow paths of debris flows. Optical remote sensing is the most fundamental and widely used remote sensing method in Earth observation systems. This technology uses optical sensors mounted on aerospace platforms to receive the visible, near-infrared, and shortwave infrared electromagnetic waves reflected or emitted by the Earth's surface, thereby acquiring surface information. Depending on the operating wavelengths and spatial resolutions of the optical sensors, rich spectral and spatial data of the Earth's surface can be obtained, providing critical evidence for geological disaster identification. (See Figure 7)

Thermal infrared remote sensing primarily works by detecting variations in surface thermal radiation to obtain temperature information. Before geological disasters occur, surface temperatures may exhibit abnormal increases or decreases due to factors such as rock fracturing, friction, and changes in ground stress. Thermal infrared remote sensing can capture these temperature anomalies, providing crucial clues for early warning of geological disasters.

The technology operates in the thermal infrared spectrum (approximately 3-14 μm wavelength), where sensors detect the thermal radiation naturally emitted by Earth's surface features. This capability is particularly valuable because temperature anomalies often precede major geological events. For instance, before a landslide occurs, the friction between rock masses and increased ground stress can lead to localized temperature increases, while groundwater accumulation might cause temperature decreases in certain areas.

The advantages of thermal infrared remote sensing include its ability to work during both day and night, penetrate thin cloud cover, and provide continuous monitoring of large areas. Modern thermal infrared sensors can detect temperature differences as small as 0.1°C, making them highly sensitive to subtle changes that might indicate impending geological activity.

In practical applications, thermal infrared data is often integrated with other remote sensing data to create comprehensive monitoring systems. Time-series analysis of thermal patterns can reveal developing trends in surface temperature variations, which, when combined with geological knowledge and historical disaster data, significantly enhances the accuracy of early warning systems. This technology has proven particularly effective in monitoring active fault zones, unstable slopes, and areas prone to sudden ground collapse.

Recent advances in thermal infrared sensor technology, coupled with improvements in data processing algorithms, have further enhanced the capability to distinguish between normal temperature fluctuations and those that might indicate impending geological disasters. This has made thermal infrared remote sensing an increasingly important tool in disaster prevention and risk management systems.

2.2 Application Status

In recent years, satellite remote sensing technology has seen increasingly widespread application in geological disaster identification. Research institutions and scholars worldwide have conducted extensive studies in this field, achieving significant results.

Earthquake Disaster Monitoring: By analyzing satellite remote sensing images before and after an earthquake for surface deformation, building damage, and secondary geological disasters triggered by the quake, it is possible to quickly assess the severity and impact of the earthquake, thereby providing decision-making support for emergency rescue efforts. For instance, in major earthquakes such as the Wenchuan and Yushu earthquakes, remote sensing technology played a vital role, gaining precious time for rescue operations.

Landslide and Debris Flow Monitoring: Satellite remote sensing enables large-scale hazard screening and real-time monitoring. Through analysis of remote sensing images of historical landslides,

geological characteristics such as topography, geomorphology, and geological structures associated with landslide occurrence can be identified, leading to the development of landslide identification models that can be applied to detect landslide risks in other regions. Furthermore, by integrating meteorological data and hydrogeological conditions, remote sensing technology can predict and provide early warnings for landslides, debris flows, and other hazards, thereby improving warning accuracy and response time.

Other Geological Disaster Monitoring: Satellite remote sensing has been widely applied in monitoring volcanic activities, ground subsidence, and mining-related geological hazards. By utilizing thermal infrared remote sensing technology to monitor thermal anomalies, terrain deformation, and gas emissions in volcanic regions, it is possible to predict the likelihood of volcanic eruptions in advance. Meanwhile, urban ground subsidence monitoring using InSAR technology not only provides scientific basis for urban planning but also supports safety assessments of underground engineering construction. Through the application of multi-source data fusion and artificial intelligence algorithms, these technologies have consistently demonstrated advantages in high precision and timeliness in practical cases, providing robust data support for geological disaster identification, early warning, and emergency response.

Overall, the application of satellite remote sensing in geological disaster monitoring has developed into a multi-dimensional and comprehensive technical system, significantly enhancing real-time monitoring capabilities and information processing efficiency for dynamic changes in geological disasters, providing solid technical support for disaster prevention and mitigation efforts. This system not only supports the identification, early warning, and emergency rescue of various types of geological disasters, but also provides an important basis for disaster management and urban planning decisions.

3. Current Development Status of Guangxi's Satellite Remote Sensing Industry

3.1 Industrial Foundation and Advantages

Guangxi is located in South China and boasts a unique geographic position along with abundant natural resources. In recent years, Guangxi has made notable progress in the satellite remote sensing industry, initially forming an industrial system that covers data acquisition, processing, analysis, and application services.

Guangxi has developed certain capabilities for acquiring satellite remote sensing data, with multiple ground receiving stations capable of receiving data from various domestic and international remote sensing satellites. At the same time, the region has also made progress in remote sensing data processing and analysis techniques, nurturing a group of professional remote sensing talents and possessing the ability to provide remote sensing application services for various sectors, including agriculture, forestry, water conservancy, land resources, and environmental protection.

Moreover, as a frontier area for China’s open cooperation with ASEAN, Guangxi enjoys a unique geopolitical advantage. Leveraging platforms such as the China-ASEAN Expo, international cooperation and exchanges in the field of satellite remote sensing have been continuously strengthened in Guangxi. Through a series of cooperative projects with ASEAN countries in areas such as data sharing, technology research and development, and application demonstrations, a solid foundation has been laid for promoting the development of the regional satellite remote sensing industry.

3.2 Existing Issues

Although Guangxi's satellite remote sensing industry has achieved certain success in its development, there are still some issues and shortcomings. Firstly, the scale of the industry is relatively small and the competitiveness of the enterprises is weak. The number of companies engaged in satellite remote sensing- related businesses in Guangxi is limited, and most of them are small in scale with relatively low technical standards and innovation capabilities. Consequently, their market influence is weak, making it difficult to form an industrial agglomeration effect or achieve economies of scale.

Secondly, the infrastructure requires improvement.The development of the satellite remote sensing industry demands high-quality infrastructure for data acquisition, transmission, storage, and processing. Currently, Guangxi still needs to further optimize and expand the layout and construction scale of satellite ground receiving stations to meet the growing demand for remote sensing data. Additionally, the construction of high-speed, stable data transmission networks and large-

scale data storage and processing centers is relatively lagging, affecting the timely acquisition and efficient utilization of remote sensing data.

Furthermore, there is a prominent talent shortage.The satellite remote sensing industry is a technology- intensive sector that requires a large number of professionals with multidisciplinary backgrounds, including remote sensing technology, geographic information systems (GIS), computer science, and geology. However, Guangxi has relatively few institutions of higher education and research in these fields, and its talent cultivation capacity is limited, making it difficult to meet the demands of rapid industrial development. This leads to a significant gap in areas such as remote sensing technology research and development, application innovation, and high-end services.

Finally, the industrial policy support system is not sufficiently developed. Compared to regions with advanced satellite remote sensing industries, Guangxi needs to strengthen its support in terms of industrial policy assistance, capital investment, and tax incentives. The lack of specialized support policies and industrial development funds for the satellite remote sensing industry makes it difficult for enterprises to obtain financing, which limits the industry's development speed and innovation capability enhancement.

4. Methods to Enhance Enterprise Competitiveness in the Satellite Remote Sensing Industry in Guangxi

4.1 Strengthen Technological Research and Innovation

Collaboration and Exchange: Guangxi enterprises should actively collaborate with domestic and international universities and research institutions, such as Wuhan University—to leverage their research capabilities to enhance their own technological level. For example, Guangxi Natural Resources Remote Sensing Institute cooperated with Wuhan University to establish the "China-ASEAN Satellite Remote Sensing Application Joint Research Center," which conducts key technology research and boosts the innovation capability of enterprises.

Technology Introduction and Absorption: Actively introduce advanced satellite remote sensing technologies from home and abroad—such as high- resolution satellite sensor technology and data processing algorithms—and, based on their own situations, digest, absorb, and innovate upon them to improve their technological competitiveness.

Increase R&D Investment: Enterprises should increase their investment in satellite remote sensing technology research and development, encourage employees to engage in technological innovation activities, enhance their independent R&D capabilities, and develop core technologies with independent intellectual property rights.

4.2 Focus on Talent Cultivation and Introduction

Building Talent Training Systems: Strengthen cooperation with regional universities and vocational colleges, promote optimization of relevant professional courses, emphasize students' practical abilities and innovative spirit, and cultivate more professional technical and skilled talents for the satellite remote sensing industry.

High-level Talent Recruitment: Develop preferential policies to attract high-level talents and innovative teams from domestic and international satellite remote sensing fields to work and start businesses in Guangxi. Through introducing talents, bring advanced technical concepts and innovative achievements to drive the growth of local talents and enterprise development.

Talent Training and Exchange: Regularly organize enterprise employees to participate in satellite remote sensing technology training and academic exchange activities, invite domestic and international experts to conduct lectures and guidance, and improve employees' professional technical level and operational capabilities.

4.3 Optimize Industrial Service System

Improve Industrial Chain: Strengthen cooperation between upstream and downstream enterprises in the industry chain, forming a complete industrial chain from satellite development, launch, data reception and processing to application services. Through industrial collaborative cooperation, achieve optimal resource allocation, reduce enterprise costs, and enhance overall industrial competitiveness.

Establish Industry Alliance: Guangxi enterprises can jointly initiate and establish a satellite remote sensing industry alliance to strengthen communication and collaboration between enterprises, jointly develop industry standards, regulate market order, avoid vicious competition. Meanwhile, through the industry alliance, build exchange and cooperation platforms to promote resource sharing and complementary advantages between enterprises.

Improve Service Quality: Enterprises should focus on enhancing the quality and precision of satellite remote sensing data products, strengthen data processing and analysis capabilities, and provide customers with high-quality, efficient, and tailored service solutions to meet the diverse needs of clients in various industries.

4.4 Strengthen Market Expansion and Brand Building

Expand Domestic and International Markets: Guangxi enterprises should fully leverage the region's geographical and policy advantages to actively expand into international markets, such as ASEAN. By promoting satellite remote sensing technologies and products with independent intellectual property rights internationally, enterprises can increase their international market share and enhance their reputation.

Brand Building and Marketing: Enhance brand construction and market promotion efforts to establish a strong brand image and corporate reputation. By participating in major domestic and international exhibitions in the satellite remote sensing field and organizing technical exchange events, enterprises can showcase their technological strengths and product features, thereby increasing brand recognition and favorability.

5. Development Status of the Satellite Remote Sensing Industry in ASEAN Countries

5.1 Overall Development Level and Demand

ASEAN countries are located in tropical and subtropical regions, covering vast areas with complex and diverse natural environments. They face threats from various geological disasters such as earthquakes, volcanoes, landslides, and debris flows, as well as natural disasters including floods, forest fires, and typhoons. At the same time, with rapid economic development and accelerated urbanization in the region, the demand for satellite remote sensing applications in areas such as land resource surveys, urban planning, environmental protection, and agricultural monitoring is continuously growing.

In recent years, the development of the satellite remote sensing industry in ASEAN countries has shown a positive trend. Some countries, such as Singapore, Malaysia, and Thailand, have made certain progress in satellite technology research and development, satellite data applications, and the development of related industries. For example, Singapore possesses advanced satellite technology and data processing capabilities, which give it a certain advantage in the commercialization of remote sensing data. Malaysia and Thailand have each launched their own remote sensing satellites and carried out a series of application projects in fields such as land resource monitoring and disaster early warning.

However, overall, the development level of the satellite remote sensing industry in ASEAN countries remains relatively low. Most countries still face significant gaps in satellite remote sensing technology, data acquisition capabilities, application services, and industrial scale. Except for a few developed nations, most ASEAN countries lack independent satellite remote sensing systems and have a high dependence on international commercial remote sensing data, which limits their ability to independently develop and promote satellite remote sensing applications.

（1）Some Countries Have Initially Established Satellite Remote Sensing Systems

Countries such as Singapore and Malaysia have initially built their own satellite remote sensing systems. For example, Singapore's Tianwang Satellite System possesses high-resolution remote sensing imaging capabilities, providing timely and accurate geospatial information for domestic and neighboring regions, which is used in urban planning, environmental monitoring, and many other fields. Malaysia has also launched several remote sensing satellites to monitor local forest resources, agricultural planting conditions, and the marine environment, thereby enhancing its capabilities in resource management and environmental governance.

(2) Most Countries Are in the Early Stages and Rely on International Cooperation

Many ASEAN countries, such as Laos and Cambodia, are still in the early stages of developing their satellite remote sensing capabilities and lack independent satellite research, development, launch, and operational abilities. These countries often rely on international cooperation to obtain satellite remote sensing data and technical support. For example, they participate in regional remote sensing projects supported by international organizations such as the Asian Development Bank or engage in bilateral cooperation with countries that have strong satellite remote sensing capabilities to acquire remote sensing data for land surveys, disaster monitoring, and other applications, thereby meeting their basic geospatial information needs and certain industry application demands.

(3) Data Applications Focused on Meeting Each Country's Core Needs

ASEAN countries tailor the application of satellite remote sensing data to their national conditions and key development areas. For instance, due to the Philippines' location in the Pacific Ring of Fire and its frequent experience of natural disasters such as typhoons, earthquakes, and volcanic eruptions, satellite remote sensing technology is primarily applied to disaster monitoring and early warning. This enables the timely acquisition of high-definition imagery of affected areas, thereby providing decision-making support for emergency rescue and post-disaster recovery. In contrast, Vietnam focuses on applying satellite remote sensing to agriculture, monitoring rice planting areas, growth conditions, and pest infestations, and supplying data support to ensure national food security and sustainable agricultural development.

(4) Challenges Related to Technology and Funding

ASEAN countries face numerous challenges in the development of the satellite remote sensing industry. Technologically, key areas such as satellite manufacturing, launching, and data processing and analysis remain relatively weak. Additionally, the scarcity of specialized professionals further restricts technological innovation and the expansion of applications. Funding is another major constraint: establishing satellite ground receiving stations, developing new remote sensing satellites, and pursuing the commercialization of remote sensing data all require substantial financial investments. Most ASEAN countries have limited economic capabilities, making it challenging to meet the financial demands necessary for the development of the satellite remote sensing industry.

5.2 Opportunities and Challenges

5.2.1 Opportunities

(1) Strong Regional Cooperation Needs: ASEAN countries share extensive common interests and cooperation needs in economic, social, and environmental fields. Satellite remote sensing technology, as a means of providing macro-level, rapid, and accurate information, plays a significant role in strengthening regional cooperation and promoting regional integration. In addressing cross-border natural disasters, environmental protection, and resource development, satellite remote sensing can provide ASEAN countries with a unified data platform and decision-making support, promoting deeper regional cooperation.

(2) Huge Potential for China-ASEAN Cooperation: China has achieved remarkable success in satellite remote sensing technology, possessing advanced satellite technology, rich data resources, and mature application experience. As China's bridgehead for cooperation with ASEAN, Guangxi plays an important role in satellite remote sensing technology transfer, application demonstration, and talent training. Through strengthening cooperation with China, especially Guangxi, ASEAN countries can introduce advanced satellite remote sensing technology, share data resources, enhance application capabilities, and jointly promote the development of the regional satellite remote sensing industry.

(3) Technological Progress and Cost Reduction: With the continuous advancement of global satellite remote sensing technology, satellite performance continues to improve, with significant enhancements in data resolution and quality, while satellite launch costs and data acquisition costs gradually decrease. This provides favorable technical and economic conditions for ASEAN countries to develop their satellite remote sensing industry, enabling them to obtain high-quality remote sensing data at lower costs and implement diverse application projects.

5.2.2 Challenges

(1) Technological Bottlenecks and Lack of Innovation Capability: ASEAN countries face numerous technological bottlenecks in satellite remote sensing research and development, such as relatively weak capabilities in key areas like satellite sensor technology, data processing and analysis algorithms, and satellite platform construction. Moreover, due to insufficient investment in research and a shortage of innovative talent, the innovation capability of the satellite remote sensing industry is lacking, making it difficult to achieve independent technological breakthroughs and develop the industry at a high-end level.

(2) Funding and Market Cultivation Difficulties: The development of the satellite remote sensing industry requires a large amount of financial investment, including in satellite development and launches, ground system construction, data processing, and application development. Many ASEAN countries have relatively low levels of economic development, and both government and enterprise funding are limited, making it hard to undertake large-scale satellite remote sensing projects. In addition,

the market for satellite remote sensing applications in ASEAN countries is not yet fully mature; market demand is fragmented, and users' awareness and acceptance of remote sensing data need improvement, adding to the challenges of industry development.

(3) Data Sharing and Security Issues: In the process of regional satellite remote sensing data sharing, issues such as data sovereignty, data security, and intellectual property protection arise. ASEAN countries, as well as their cooperation with China and other nations, need to establish a comprehensive data sharing mechanism and security guarantee system to ensure the legal, secure, and effective utilization of data while protecting the legitimate rights and interests of all parties involved.

6. Learning from Domestic and International Satellite Remote Sensing Industry

6.1 International Experience United States

The United States is the global leader in the satellite remote sensing industry, having accumulated rich experience in satellite technology development, data commercialization, and industrial development policies.

The U.S. possesses advanced satellite remote sensing technology, including various types of satellite systems such as high-resolution optical satellites and radar satellites, capable of providing high-quality remote sensing data worldwide. Its satellite remote sensing industry presents a diversified development pattern, featuring both government-led public remote sensing data services and numerous commercial remote sensing companies engaged in data sales and customized application services. For example,DigitalGlobe (now a subsidiary of Maxar Technologies) is a globally leading commercial remote sensing satellite operator, whose high-resolution satellite imagery is widely used in defense, intelligence, cartography, environmental monitoring, and many other fields, achieving breakthroughs in commercial applications.

Regarding industrial development policies, the U.S.

government encourages the development of the commercial satellite remote sensing industry through relevant laws, regulations, and policies, while strengthening the supervision of remote sensing data security and privacy protection. The government has invested in building a series of fundamental satellite remote sensing infrastructure and makes certain data publicly available, providing basic data support for commercial applications. Additionally, the U.S. emphasizes remote sensing technology research and development and talent cultivation, establishing numerous related majors and research programs in universities and research institutions, ensuring an adequate supply of high-quality talent for industry development.

EU(European Union)

The European Union's Copernicus Program is one of the world's largest Earth observation initiatives. By launching a diverse set of satellites, a robust satellite remote sensing monitoring system has established that delivers high-quality environmental and climate data for both Europe and the global community. The program's success is largely attributed to the tight collaboration among EU member states and a well-coordinated policy framework. Countries work together in satellite technology development, data sharing, and application promotion, ensuring optimal resource allocation and complementarity. Additionally, the establishment of a unified data platform and standardized data products has spurred extensive use and commercialization of remote sensing data across various applications, including atmospheric, oceanic, and land monitoring, as well as climate change analysis, all of which support environmental policy, disaster management, and agricultural development in Europe.

Japan

Japan has achieved significant advancement in satellite remote sensing technology, particularly in disaster monitoring and management applications. The Japanese government places high priority on the research, development, and application of satellite remote sensing technology, integrating it as a crucial component of the national disaster prevention and mitigation system.

Through a combination of independent development and international cooperation, Japan has established a monitoring network comprising multiple remote sensing satellites capable of timely detection and assessment of natural disasters such as earthquakes, typhoons, and floods. In terms of data processing and applications, Japan has developed a series of advanced remote sensing data processing algorithms and models, enabling rapid analysis and precise interpretation of remote sensing data. For example, following earthquake events, satellite imagery can be quickly utilized to assess building collapse areas and road damage

extent, providing decision support for emergency rescue operations.

6.2 Domestic Experience:

National Level:

In 2015, the State Council issued the "Medium and Long-Term Development Plan for National Civil Space Infrastructure (2015–2025)," which provided top-level design for the development of the satellite remote sensing industry, clearly defining development goals and key tasks, and driving rapid industry growth. At the same time, the state increased funding for the satellite remote sensing industry, supporting key technology research and development as well as major project construction.

Local Level (Taking Guangxi as an Example):

Guangxi has established a "1+8+N" co-construction and sharing model, building 14 municipal sub-centers and 65 county-level nodes. This has led to the preliminary construction of a four-tier (Ministry–Province–City–County) natural resource satellite application technology system in Guangxi, which provides technical support for comprehensive local natural resource supervision.

7. Opportunities and Challenges for the Development of Satellite Remote Sensing Industry in Guangxi and ASEAN Countries

7.1 Opportunities

Cooperation Opportunities under the "Belt and Road" Initiative: The "Belt and Road" initiative provides a broad platform for collaboration in the field of satellite remote sensing between China and ASEAN countries. Guangxi, as an important gateway city seamlessly connected with the "Belt and Road," holds unique advantages in promoting satellite remote sensing industry cooperation with ASEAN nations. By strengthening cooperation with countries along the route in areas such as infrastructure connectivity, spatial information sharing, and coordinated disaster prevention and control, Guangxi can fully leverage its strengths in satellite remote sensing technology and industry to expand into overseas markets and drive the coordinated development of the regional satellite remote sensing industry.

Support from National Strategies such as "Science and Technology Revitalizing Mongolia": A series of policies implemented by the nation to support technological innovation and industrial upgrading in the western region provides strong policy backing and funding support for the development of Guangxi's satellite remote sensing industry. Guangxi can seize these policy opportunities to increase investment in the satellite remote sensing industry, strengthen infrastructure development, cultivate innovative talents, and enhance the overall competitiveness of the industry.

Demand from the Upgraded Development of the China-ASEAN Free Trade Area:

With the continuous upgrading and development of the China-ASEAN Free Trade Area, cooperation between the two sides in trade, investment, and technology is deepening. As an emerging industry with broad application prospects and market potential, the satellite remote sensing industry can provide critical technical support, and service guarantees for the establishment and development of the free trade area. For instance, in cross-border resource development, ecological and environmental protection, and marine monitoring, satellite remote sensing can offer real-time and accurate information, thereby promoting win-win cooperation.

Rapid Development and Application Expansion of Satellite Remote Sensing Technology: Continuous innovation and progress in global satellite remote sensing technology have provided technical support for the development of the satellite remote sensing industry in Guangxi and ASEAN countries. With the emergence of high-resolution, high-precision, and multispectral satellite sensors, as well as increasingly intelligent and automated remote sensing data processing and analysis techniques, and significant advances in satellite communication and data transmission technology, the applications of satellite remote sensing have been continuously expanding. These technological achievements have made satellite remote sensing more widely and deeply applied in fields such as geological disaster monitoring, smart agriculture, intelligent transportation, and smart city development, thus bringing new growth points for industry development.

6.2 Challenges

Intensifying International Competition: Global satellite remote sensing market competition is becoming increasingly fierce, with developed countries and emerging economies increasing their investment in the satellite remote sensing industry to capture market share and technological high ground. Guangxi and ASEAN countries have relatively lower development levels in the satellite remote sensing industry and weaker competitiveness in the international market, facing significant competitive pressure from advanced international

enterprises. How to enhance their technological innovation capabilities and service quality, and build internationally competitive satellite remote sensing brands, is a major challenge facing Guangxi and ASEAN countries.

Insufficient Innovation and Technology Transfer Capabilities: Despite some progress in satellite remote sensing technology applications, Guangxi and ASEAN countries still face significant gaps in core technology innovation and achievement transformation. Factors such as insufficient research investment, shortage of innovative talent, and weak industry-academia-research integration have constrained the improvement of independent innovation capabilities and industrial application promotion of satellite remote sensing technology. Establishing effective technology innovation systems and achievement transformation mechanisms, accelerating the transformation of scientific and technological achievements, and increasing industrial added value are urgent issues to be addressed.

Insufficient Industry Coordination and Collaboration: The development of the satellite remote sensing industry requires coordinated cooperation across multiple departments, fields, and regions. However, there are still numerous issues in terms of collaborative efforts among Guangxi and ASEAN countries in this field. Problems such as poor data sharing between departments, unbalanced industrial development across regions, and insufficient cooperation between upstream and downstream enterprises in the industry chain are prevalent. These issues lead to wastage of industrial resources and frequent instances of redundant construction, negatively impacting the overall efficiency and effectiveness of industry development.

Imperfect Policy Regulations and Standard Systems: The development of the satellite remote sensing industry involves multiple aspects, such as national security, data security, and intellectual property protection, which require comprehensive policy regulations and standard systems to ensure protection. Currently, Guangxi and ASEAN countries lag behind in the construction of policy regulations and standard systems for satellite remote sensing. Issues such as incomplete policies and inconsistent standards pose potential risks to the healthy development of the satellite remote sensing industry.

7. Strategies for Building the Satellite Remote Sensing Industry System in Guangxi and ASEAN Countries

7.1 Strengthen Institutional Management and Policy Support

Formulated Industry Development Strategic Planning: Guangxi and ASEAN countries should jointly formulate strategic plans for satellite remote sensing industry development based on their own development needs and advantages. These plans should clearly define industry development goals, key areas, and implementation steps to guide orderly industry development. In the planning process, full consideration should be given to regional industrial collaborative development needs to avoid redundant construction and destructive competition.

Improve the Policy and Regulation System: Accelerate the formulation and improvement of policies and regulations related to the satellite remote sensing industry, including data sharing policies, intellectual property protection policies, and data security management measures, to provide a favorable policy environment and legal protection for industry development. At the same time, efforts should be strengthened to publicize, implement, and supervise these policies and regulations to ensure their effective implementation.

Increase Fiscal and Financial Support: The government should establish a dedicated industrial development fund and increase fiscal investment in the satellite remote sensing industry, with a focus on supporting key technology research and development, infrastructure construction, application emonstration projects, and talent cultivation. Furthermore, financial institutions should be guided to increase credit support for satellite remote sensing enterprises and to innovate financial products and service models, thus providing diversified financing channels for industry development.

7.2 Strengthen Infrastructure Construction

Optimize the layout of satellite ground receiving stations, expand construction scale, and improve reception efficiency. Upgrade data transmission and storage facilities by establishing high-speed transmission networks and large-scale data storage centers. Promote the construction of integrated infrastructure by facilitating technology integration, creating an all-in-one spatial information platform, and developing an efficient data processing and analysis platform. Enhance the shared construction of infrastructure, promote regional cooperation and inter- departmental

coordination, and achieve optimal allocation and complementarity of resources.

(1) Optimize Satellite Ground Receiving Station Layout

Expand Construction Scale:

Further optimize the layout of Guangxi's satellite ground receiving stations

Increase the number of receiving stations

Enhance satellite remote sensing data reception capabilities

Ensure timely and complete reception of data from multiple domestic and international remote sensing satellites

Improve Reception Efficiency:

Upgrade technology and equipment at existing ground stations

Enhance satellite signal capture, tracking, and reception efficiency

Reduce data loss rates

(2) Upgrade Data Transmission and Storage Facilities

Build High-Speed Transmission Networks:

Strengthening the construction of high-speed, stable data transmission networks

Improve transmission efficiency and quality of satellite remote sensing data

Ensure rapid and accurate data transmission to processing centers and users

Establish Large-Scale Data Storage Centers:

Build cloud computing platforms or data centers with large-scale storage and management capabilities

Meet massive remote sensing data storage requirements

Focus on data backup security and recovery capability development

(3) Promote Integrated Technology Infrastructure Build an Integrated Spatial Information Platform:

Strengthen infrastructure for integrated applications of satellite remote sensing with GIS, GPS, IoT, big data, and AI

Create unified spatial information service platform

Enable multi-source data fusion, sharing, and collaborative processing

Establish Remote Sensing Data Processing and Analysis Platform:

Build efficient, precise remote sensing data processing and analysis platforms

Integrate advanced data processing algorithms and analysis models

Improve data processing efficiency and analysis accuracy

Provide quality data products and services

(4) Strengthen Shared Infrastructure Development Promote Regional Cooperation:

Enhance cooperation with neighboring provinces and ASEAN countries in infrastructure construction

Jointly build regional satellite remote sensing data reception, processing, transmission, and storage sharing networks

Achieving optimal resource allocation and complementarity

Facilitate Departmental Coordination:

Promote shared infrastructure construction among different departments within Guangxi

Break down departmental data barriers

Enable interconnection and sharing of satellite remote sensing data

Improve infrastructure utilization efficiency

7.3 Focus on Talent Cultivation and Introduction

Strengthen talent cultivation systems in universities and research institutions: Universities and research institutions in Guangxi and ASEAN countries should enhance the establishment and development of satellite remote sensing-related majors, optimize curriculum systems, and emphasize students' practical abilities and innovative spirit. They should strengthen industry-academia-research cooperation, establish internship and training bases, provide practical training opportunities for students, and improve the quality of talent cultivation.

Attract high-level talents and innovative teams: Develop preferential policies to attract high-level talents and innovative teams in the field of satellite remote sensing from both domestic and international sources to work and start businesses in Guangxi and ASEAN countries. Through the introduction of talent, bring advanced technical concepts and innovative achievements, driving the growth of local talent and the improvement of industrial development levels.

Conduct talent training and exchange activities: Regularly organize satellite remote sensing technology training and exchange activities, invite domestic and international experts to provide lectures and guidance, and improve the professional technical level and operational capabilities of practitioners. Meanwhile, encourage enterprises and research institutions to select outstanding talents for learning and exchange opportunities in advanced domestic and international regions, broadening their horizons and enhancing their technical capabilities.

7.4 Promote Technological Innovation and Application

Strengthen key technology research and development: Guangxi and ASEAN countries should increase investment in satellite remote sensing key technologies, focusing on breakthroughs in high- resolution satellite sensor technology, multi-source remote sensing data fusion technology, intelligent remote sensing data processing and analysis technology, and satellite communication and data transmission technology. Through technological innovation, improve the quality and application value of satellite remote sensing data and enhance the industry's core competitiveness.

Expand and deepen application fields: While consolidating existing satellite remote sensing applications, actively explore new application areas such as smart emergency care, marine monitoring and management, cultural heritage protection, and precision marketing. Additionally, deepen the application of satellite remote sensing technology in traditional fields through integration with other technologies to provide higher quality, more efficient, and precise service solutions for various industries, promoting integrated industrial development.

Establish industry-academia-research-user collaborative innovation mechanisms: Strengthen cooperation between enterprises, universities, research institutions, and users to establish collaborative innovation mechanisms that promote deep integration of technological achievements with industry. Through joint research projects, shared innovation platforms, and scientific equipment sharing, achieve complementary advantages, accelerate the transformation of scientific and technological achievements, and enhance industrial innovation capabilities.

8. Conclusions

Satellite remote sensing technology offers irreplaceable advantages in geological disaster identification and monitoring. It quickly and accurately captures large-scale surface information, providing essential data for early warning, emergency response, and recovery. The conclusion emphasizes leveraging its strengths to enhance system management, infrastructure development, talent cultivation, and technological innovation. The strategies recommended include strengthening institutional policies, improving supporting infrastructure, fostering talent and expertise, driving technology advancements, and refining industry policies. Ultimately, integrating satellite remote sensing within a comprehensive smart emergency care model ensures rapid disaster detection, prediction, and coordinated response, thereby safeguarding lives, protecting assets, and promoting sustainable regional development.

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Fund: Research on the Development of Satellite Remote Sensing Industry in Guangxi Facing ASEAN Countries, a 2025 key topic of the Guangxi Science and Technology Community Think Tank self-funded category under project No. Gui Kexie [2025] K-037, with Yan Qiuyi as the principal investigator.

Figure 1: Research technology roadmap

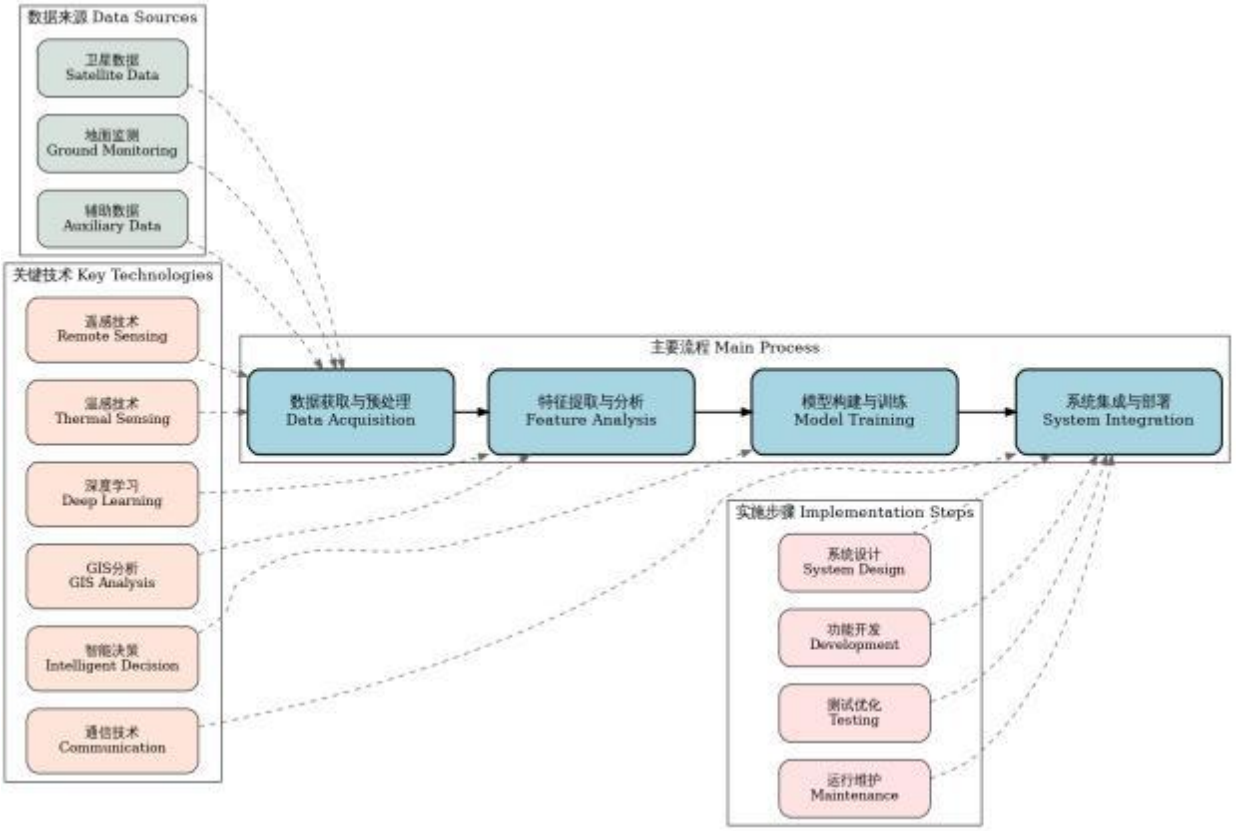


Figure 2: Overview of the Principles and Applications of InSAR Technology

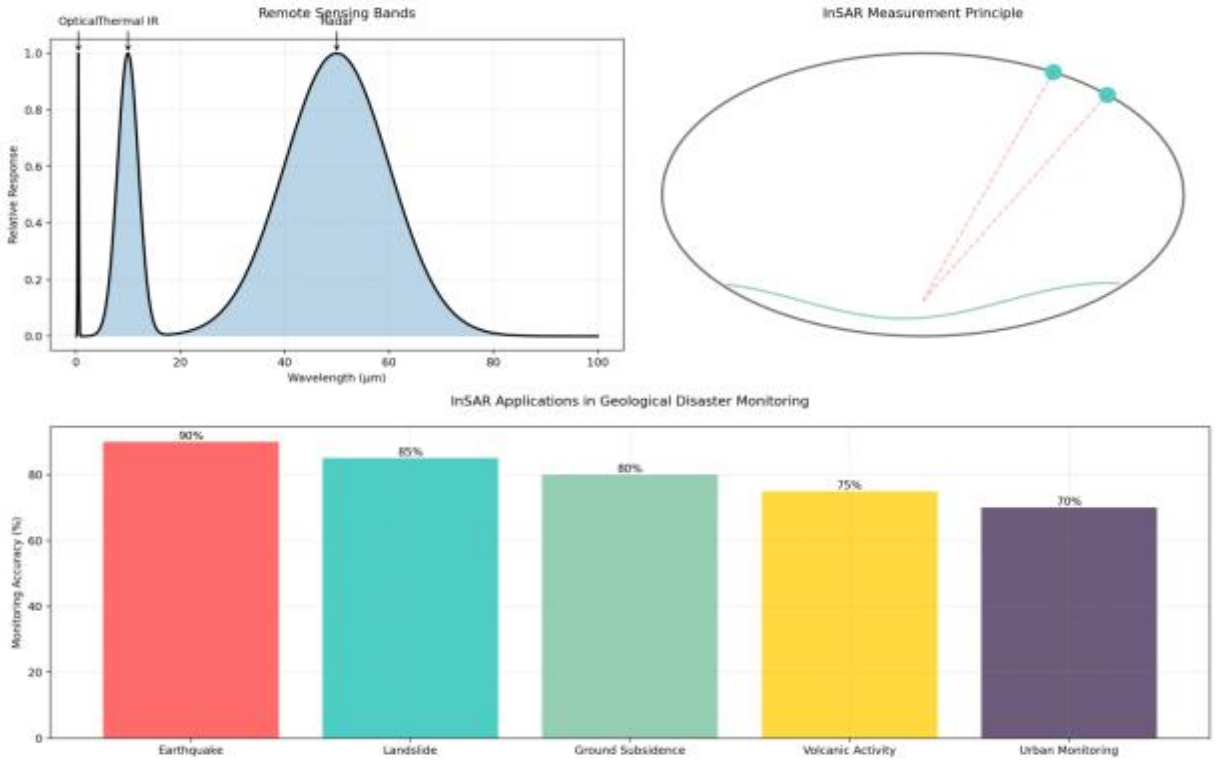


Figure 3: Timeline of InSAR Technology Development

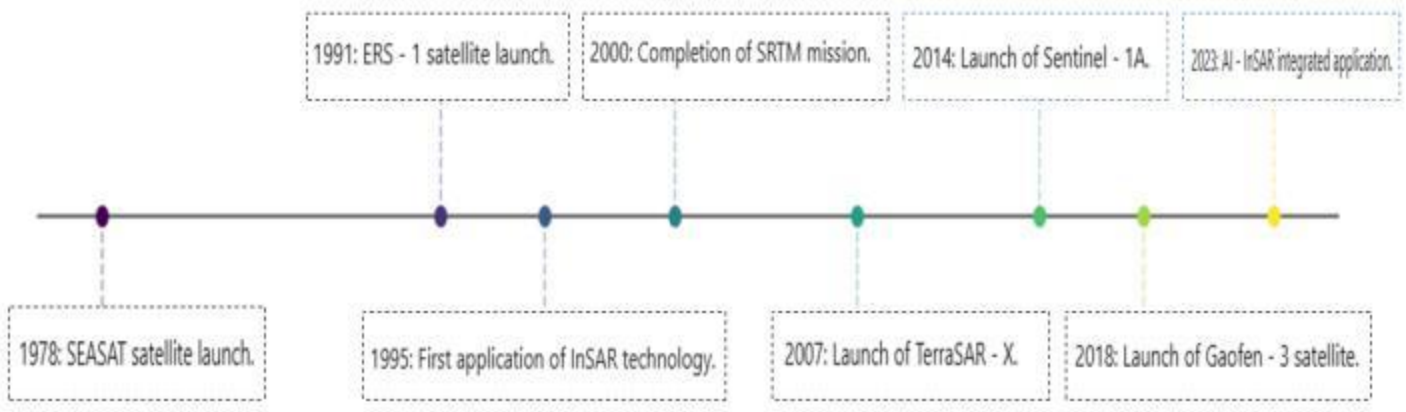


Figure 4: InSAR Technology Processing Workflow

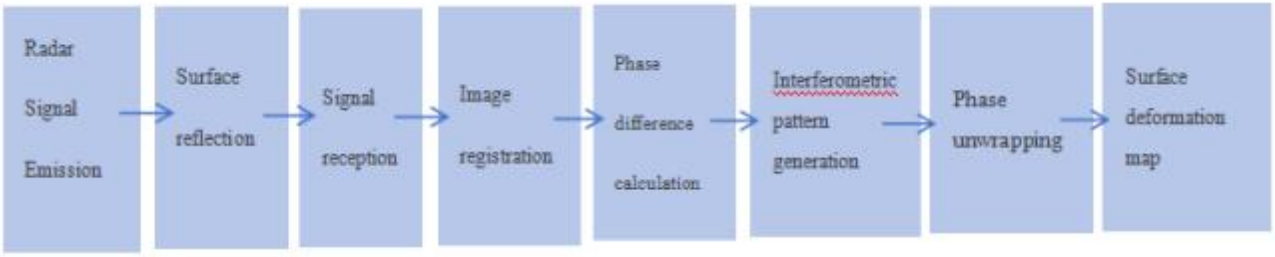
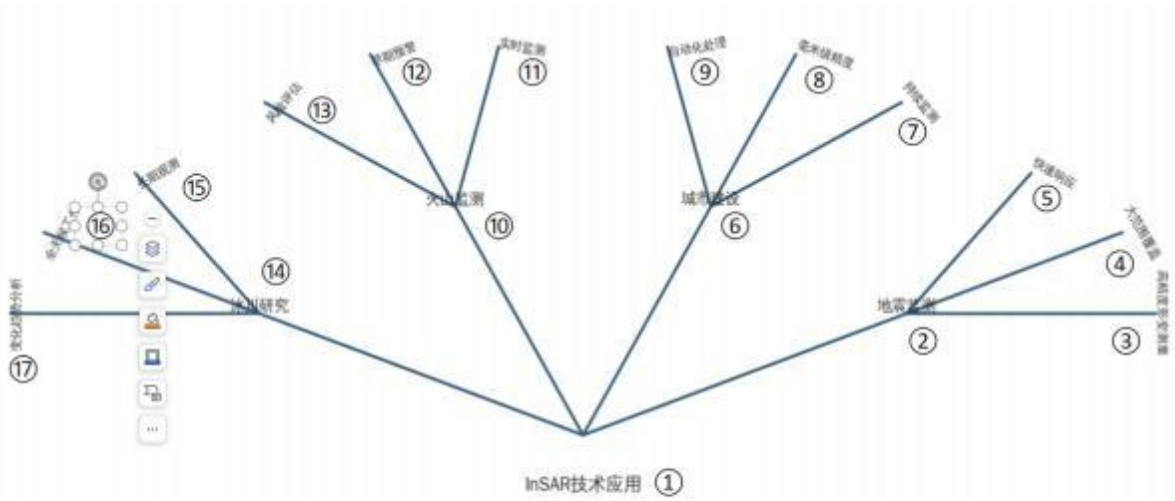
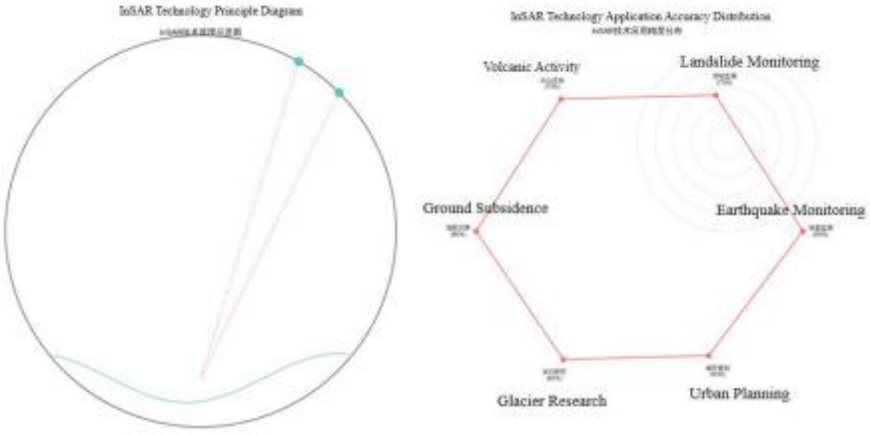


Figure 5: InSAR Technology Application Scenarios



1. InSAR Technology Applications
2. Earthquake Monitoring — 3. High - Precision Deformation Measurement 4. Wide - Area Coverage 5. Rapid Response
6. Urban Construction —7. Continuous Monitoring 8. Millimeter - Level Precision 9. Automated Processing
10. Volcano Monitoring:11. Real - Time Monitoring 12. Early Warning 13. Risk Assessment
14. Glacier Research:15. Long - Term Monitoring 16. All - Weather Operation 17. Trend Analysis of Changes

Figure 6 InSAR Technology Principles and Its Application Domains



Note: The left side shows a schematic diagram of the technical principles, illustrating the satellite orbit and radar signal transmission path; the right side features a hexagonal network diagram displaying the monitoring precision distribution ofInSAR across different application domains, visually reflecting the technology's effectiveness in various fields.

Figure 7: Spectral Characteristics, Application Domains, and Accuracy of Optical Remote Sensing

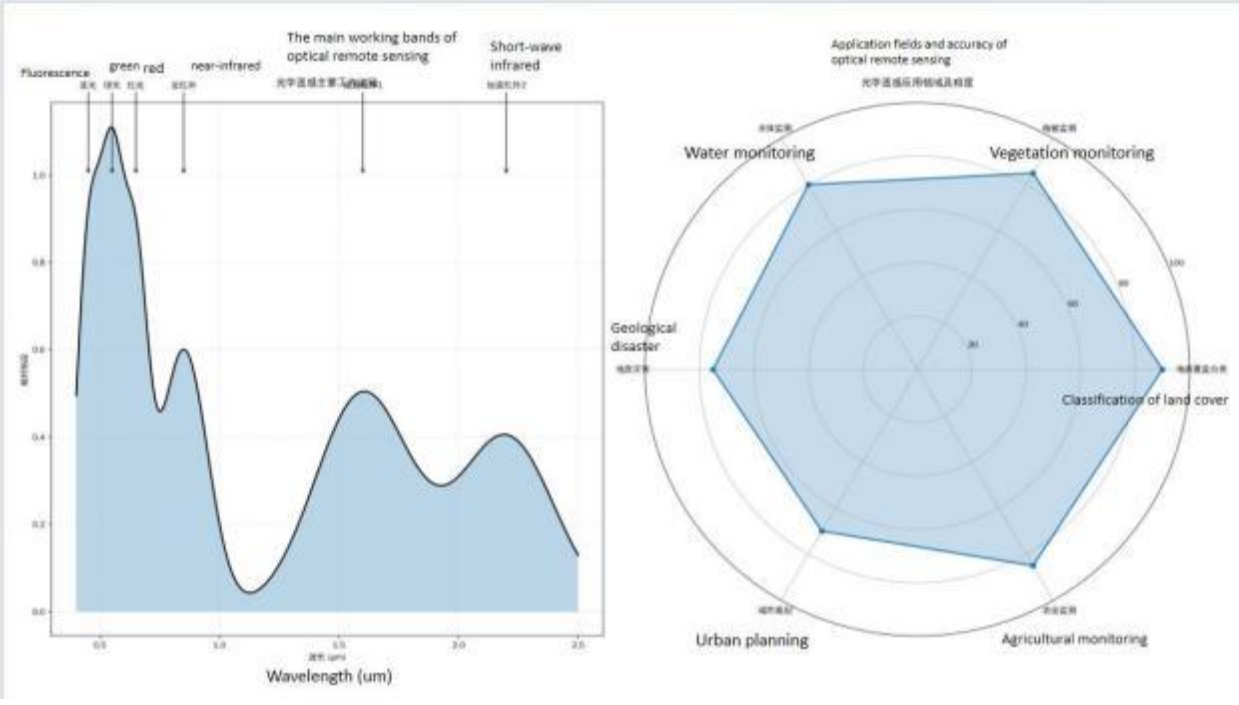


Figure 8: Development Timeline of Optical Remote Sensing