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CONTENTS

A Study on the Application of SOLO Taxonomy Theory in the Evaluation of English Writing in Junior High School

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Abstract: This study explores the application of SOLO (Structure of the Observed Learning Outcome) Taxonomy in evaluating junior high school students' English writing, aiming to verify its effectiveness in improving writing competence and self-efficacy. Using a mixed-methods approach, the research conducted a 6-week experiment with two parallel 7th-grade classes: the experimental class adopted SOLO-based assessment with hierarchical feedback, while the control class used traditional holistic scoring. Data from writing tests, self-efficacy questionnaires, and semi-structured interviews were analyzed. Results showed significant differences in post-test writing scores between the two classes ($p < 0.05$), with the experimental class demonstrating greater improvements in cognitive levels (e.g., increased proportion of relational and extended abstract levels), content depth, structural logic, and linguistic complexity. Additionally, students in the experimental class exhibited significant enhancements in self-efficacy across three dimensions: idea generation, writing conventions, and self-regulation. Interview findings further confirmed that SOLO-based assessment facilitated precise problem identification, improved logical awareness, and boosted learning motivation. This study concludes that SOLO Taxonomy provides a feasible and effective evaluation model for junior high school English writing, offering practical implications for differentiated teaching and process-oriented assessment.

Keywords: SOLO Taxonomy; Junior High School English; Writing Assessment; Writing Competence; Self-efficacy

1. RESEARCH BACKGROUND AND PURPOSE

The Compulsory Education English Curriculum Standards (2022 Edition) clearly stipulate that the core competencies to be cultivated in English courses encompass language proficiency, cultural awareness, thinking qualities, and learning abilities. Writing, as a comprehensive skill, integrates students' language proficiency and critical thinking, serving as a concentrated manifestation of their overall English learning outcomes and the four dimensions of core competencies. In English writing instruction, teacher assessment plays a pivotal role. Currently, assessment methods for secondary school English writing can be broadly categorized into two types: holistic scoring and analytic scoring. Holistic scoring, predominantly used in junior high school writing assessment due to its time-efficiency, involves teachers assigning scores based on overall impressions. However, this approach provides students with only a vague understanding of their writing proficiency level, leaving them unaware of specific weaknesses and uncertain about strategies for improvement. Moreover, students exhibit significant individual differences in reading and writing, manifested in language use, content development, and structural organization. Ignoring these disparities in instructional design undermines the effectiveness and pertinence of teaching.

SOLO (The Structure of the Observed Learning Outcome) taxonomy, proposed by John Biggs and Kevin Collis in 1982, is a hierarchical model for analyzing learning outcomes. It categorizes the learning process into five developmental levels: prestructural, unistructural, multistructural, relational, and extended abstract. This theory not only enables systematic evaluation of students' learning achievements but also offers scientific guidance for instructional practice, demonstrating particular strengths in fostering critical thinking and enhancing learning outcomes. Inspired by these advantages, this study innovatively applies the SOLO taxonomy to the assessment system of junior high school English writing, aiming to promote the dual improvement of students' writing proficiency and self-efficacy through stratified and precise evaluation models.

This research focuses on empirically exploring the application value of the SOLO taxonomy in junior high school English writing assessment. Through instructional interventions implemented in experimental and control classes, it systematically validates the practical efficacy of the theory in writing instruction. The study is guided by the following specific objectives:

First, a refined assessment criteria tailored to junior high school English writing will be developed based on the five-level evaluation framework of the SOLO taxonomy. This enables teachers to provide targeted feedback and guidance according to students' writing performance at different cognitive levels, helping

students clarify their developmental trajectories and gradually enhance their writing skills.

Second, the research aims to investigate the impact of the SOLO taxonomy on students' writing self-efficacy. By adopting a structured, progressive assessment approach, teachers can identify students' incremental progress, offer personalized feedback, and provide encouragement, thereby boosting students' confidence and motivation in writing and strengthening their internal drive for self-improvement.

Third, through empirical research, the study seeks to verify the effectiveness and feasibility of applying the SOLO taxonomy in junior high school English writing assessment. By comparing the instructional outcomes of experimental and control classes and quantitatively analyzing the influence of the theory on dimensions such as writing quality and thinking depth, this research provides replicable practical paradigms for English writing instruction. Additionally, it expands the application scope of the SOLO taxonomy within the English discipline, offering novel theoretical support and practical references for interdisciplinary educational research.

2. INTRODUCTION OF SOLO TAXONOMY THEORY

2.1 The Basic Connotation of the SOLO Taxonomy Theory

Biggs et al. developed the SOLO taxonomy theory based on Piaget's theory of cognitive development stages. Piaget proposed that children's cognitive development progresses through the sensorimotor stage (0–2 years), preoperational stage (2–7 years), concrete operational stage (7–11/12 years), and formal operational stage (11/12 years and above). The SOLO taxonomy theory partially acknowledges the stage-based nature of cognitive development. However, in practice, Biggs and his colleagues found that students' problem-solving performances did not strictly align with these stages. For example, a student might reach the formal operational stage in mathematics but remain at the concrete operational stage in geography. Practical evidence shows that Piaget's theory struggles to determine a student's thinking development stage, as overall cognitive structure—termed by Biggs as the hypothetical cognitive structure (HCS)—is a purely theoretical construct difficult to measure. In contrast, an individual's thinking structure can be assessed by their response to a specific question, which is observable: the structure of the observed learning outcome (SOLO).

2.2 The Main Content of the SOLO Taxonomy Theory

Informed by British psychologist Edwin Peel's research, Biggs et al. conducted in-depth observations of student learning and identified a universal developmental pattern: from acquiring isolated, unrelated information initially to forming interconnected, coherent knowledge systems through qualitative changes in deep learning. This process reflects a quantitative-to-qualitative transition in thinking, culminating in the establishment of abstract systems and new dimensions. Biggs also argued that cognitive development stages in learning new knowledge involve not only quantitative differences but also qualitative leaps in cognitive levels.

Analyzing hundreds of students' responses to disciplinary questions, they found consistent patterns in response structures across different subjects and contexts. Based on four dimensions—ability, thinking operations, consistency and closure, and response structure—they classified responses into five hierarchical levels (Biggs & Collis, 1982; Xu Huan, 2011; Lu Mei, 2014):

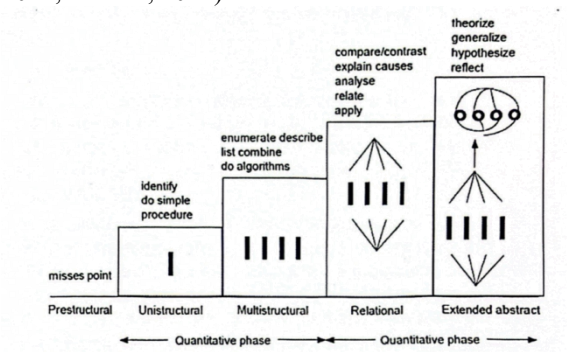

Figure 1 The 5 levels of thinking hierarchy in the SOLO Taxonomy

Figure 1 shows the main content of the SOLO Taxonomy:

Prestructural level: Students lack foundational knowledge and skills, misinterpret questions, or are distracted by irrelevant factors, leading to illogical, repetitive, or irrelevant responses.

Unistructural level: Students grasp partial content but draw hasty, one-sided conclusions from single clues, oversimplifying or deviating from accurate reasoning.

Multistructural level: Students identify multiple clues but fail to integrate them, resulting in fragmented answers without considering interconnections.

Relational level: Students holistically understand questions, integrate all clues and their internal relationships, and solve problems through comprehensive analysis.

Extended abstract level: Students not only extract factual information but also deduce novel hypotheses by integrating logical deduction and abstract extension, demonstrating strong creativity and learning engagement.

The SOLO taxonomy theory is visually represented as follows (Biggs, 1995) [insert figure]. It provides a universal framework for determining the hierarchy of learning processes by matching observable learning outcomes to the five levels. Notably, these levels are not absolute: when a student's performance falls between two levels (e.g., unistructural and multistructural), a "transitional response" is used to indicate the intermediate state.

2.3 The Characteristics of the SOLO Taxonomy

Theory

As a key framework for learning outcome assessment, the SOLO taxonomy theory features:

Focus on observable learning outcomes: It evaluates explicit, observable responses to specific tasks, using reaction patterns and thinking processes to determine cognitive development and thinking levels.

Integration of quantitative and qualitative evaluation: While unistructural and multistructural levels measure knowledge quantity ("what is learned"), the transition to relational/extended abstract levels assesses qualitative thinking development—such as integrating multiple elements ("how to learn").

Unity of content and process: Unlike Bloom's taxonomy, which separates content from process, SOLO emphasizes the integration of knowledge and process skills in thinking, examining both factual understanding and task-specific thinking strategies.

Practical operability: By shifting focus from abstract "behaviors" to concrete learning outcomes, SOLO enhances evaluation validity and reliability. It efficiently assesses thinking levels in open-ended tasks, particularly at the relational and extended abstract stages, which reflect strong problem-solving abilities.

3. LITERATURE REVIEW

Studies on the SOLO taxonomy theory can be broadly categorized into two types: those providing an overall introduction to the theory and those applying the theory to various disciplines.

3.1 Studies on the Overall Introduction to the SOLO Taxonomy Theory

Such studies are further divided into two categories:

Single-introduction studies on the SOLO taxonomy theory: A representative work is Professor Wu Weining's New Concepts in Educational Evaluation: An Introduction to the SOLO Evaluation Method, which outlines the origin of the SOLO taxonomy theory, introduces its framework and grading methods, and explains that it is a two-dimensional evaluation system. In How to Grade Open-ended Questions? Introducing Two Qualitative Grading Methods, Professors Gao Lingbiao and Wu Weining classify open-ended questions and propose the applicable scenarios, advantages, and disadvantages of the SOLO taxonomy and PTA scale method, bringing new perspectives to qualitative grading of open-ended questions in China.

Professor Wu Weining, together with Li Jia and Kong Huis, proposed the Guttman scale as a tool for quality testing of SOLO-based questions, laying the foundation for better integration of the SOLO taxonomy theory with subjective questions. Huang Liming and Yan Suifen pointed out that the SOLO taxonomy theory is highly operational, suitable for China's teaching and evaluation, and easy to promote, while also noting its practical limitations—for example, it is less suitable for large-scale selection exams, requires more research data and cases, and needs localization. Professor Wu Youchang compared the SOLO taxonomy theory with Bloom's Taxonomy of Educational Objectives, highlighting the former's breakthroughs based on the value and issues of the latter. Feng Cuidian, Professor Gao Lingbiao, etc., discussed the ten-year development of the SOLO taxonomy theory in Chinese educational research and proposed suggestions such as deepening its application in evaluating open-ended questions and emphasizing its practical use in teaching. Li Chunyu analyzed the advantages and disadvantages of the SOLO taxonomy theory in teaching evaluation.

Studies applying the SOLO taxonomy theory to teaching: A classic example is Professor Cai Yonghong's in-depth analysis of the theory's content, proposing its characteristics and potential issues in teaching applications. Professors Wu Youchang and Gao Lingbiao also introduced methods for applying the SOLO taxonomy theory in teaching evaluation, laying a foundation for its practical use in this field.

3.2 Research on the Application of the SOLO Taxonomy Theory in Various Disciplines

The SOLO taxonomy theory, from the perspective of qualitative research, has brought new approaches to evaluating subjective questions in various disciplines. Since its introduction, Chinese academia has explored its application in educational evaluation, with scholars applying it to mathematics, English, Chinese, history, geography, science, etc.—particularly in history. In 2006, Guangdong introduced the SOLO taxonomy theory into history questions for middle and high school entrance exams, followed by eastern cities like Shanghai, achieving notable results. The history discipline has seen the closest and most successful integration with the SOLO taxonomy theory, as outlined below:

In the exploration of integrating the SOLO taxonomy theory with history, Professor Huang Muhang made significant contributions. Taking material-based and essay questions as examples, he specified methods for classifying response levels in history problems using the SOLO taxonomy, proposed approaches to designing history questions based on this theory, and pointed out that SOLO-based questions differ from traditional ones mainly in the openness of answers. Kang Zheng conducted an empirical study on integrating the SOLO taxonomy theory with history teaching to improve students' historical thinking skills, identifying practical issues, constraints, and countermeasures. Sun Lihua proposed strategies for students to answer SOLO-based history questions in college entrance exams and for teachers to design relevant instruction. An Shihao analyzed the formats and assessment objectives of SOLO-based history questions in the college entrance exam. Liao Huahong and He Qiong found that the two-grader method ensures high reliability when using the SOLO taxonomy theory for large-scale testing.

In English, applied and empirical research on the

SOLO taxonomy theory remains limited. Notable studies include Xu Xiaoyan's high-quality example analysis of The Gift of the Magi reading comprehension using the SOLO taxonomy, vividly demonstrating its application in English reading. Professor Zhang Hongyan proposed implementation plans for applying the SOLO taxonomy theory in summative evaluations of high school English compulsory modules. Lu Mei conducted experimental research and teaching trials in middle schools to improve high school students' reading skills, showing that the SOLO taxonomy theory can accurately assess students' thinking levels and enhance their reading abilities.

Research on applying the SOLO taxonomy theory to English writing is scarce. Ma Li pioneered this field by illustrating its application in writing evaluation through a case study,[3] while Chen Yanhang applied it to junior high school English writing teaching, conducting experiments to improve students' thinking skills and confirming the theory's effectiveness in testing thinking levels.

4. THEORETICAL FRAMEWORK

4.1 Piaget's Cognitive Development Theory

Piaget (1950) proposed that children's cognitive development can be divided into four stages: the sensorimotor stage, the preoperational stage, the concrete operational stage, and the formal operational stage. Among them, the concrete thinking stage is further divided into the primary concrete thinking stage, the intermediate concrete thinking stage, and the general concrete thinking stage according to age characteristics.

The SOLO taxonomy is often categorized as a "neo-Piagetian theory" because it inherits the core ideas of Piaget's cognitive development theory. Both theories argue that cognitive development is stage-based and focus on students' real learning contexts in educational environments and their reactions in the cognitive process, rather than merely focusing on cognitive outcomes. However, the SOLO taxonomy places more emphasis on observing learning outcomes, which can scientifically reflect the levels of human thinking structures. Research on this theory has shown that the form, quantity, and disciplinary quality of any outcomes generated in the learning process are influenced by the teaching procedures in the learning exploration stage and the stage characteristics of students. Therefore, it is particularly important to pay attention to the development of students' thinking structure levels.

4.2 Bloom's Taxonomy of Educational Objectives

American educational psychologist Bloom divided the educational objective system into three domains (Anderson & Krathwoh, 2001): the cognitive domain, the affective domain, and the psychomotor domain. The educational objectives of each domain can be further divided into several levels. For example, the educational objectives of the cognitive domain are divided into six levels: remembering, understanding, applying, analyzing, synthesizing, and evaluating.

Bloom's Taxonomy of Educational Objectives provides educators with ideas on how to effectively propose hierarchical questions and offers a framework for grading the difficulty of question selection based on learners' actual levels, which has become the basis for most current examination paper designs. Its theoretical system is more systematic.

Different from Bloom's taxonomy, which artificially separates content from process, the SOLO classification evaluation emphasizes the close integration of knowledge and process skills in the thinking process. This theory not only focuses on students' acceptance and understanding of facts and concepts but also explores the thinking patterns and learning strategies formed by students in response to specific learning tasks during the learning process.

The SOLO classification evaluation has changed the way Bloom's taxonomy measures learning outcomes by assessing changes in students' learning behaviors (since the meaning of "behavior" is abstract and difficult to accurately evaluate). Its evaluation objectives are clear and specific, which improves the validity and reliability of evaluation. It can effectively assess students' performance in completing open-ended learning tasks and judge their thinking levels in a short period..

5. RESEARCH METHODOLOGY

5.1 Overview of Research Methods

This study employs a mixed-methods approach, integrating quantitative and qualitative analyses to systematically investigate the application efficacy of writing assessment models based on the SOLO taxonomy theory in junior high school English writing instruction. Through controlled experiments, standardized scale surveys, and in-depth semi-structured interviews, the research focuses on the impact mechanisms of this assessment model on students' writing competence development and self-efficacy enhancement. The methodological framework encompasses research question formulation, experimental sample selection, research instrument development (including test papers, questionnaires, and interview protocols), and data collection through a three-stage empirical process (pre-test, intervention, post-test), with final statistical analysis and qualitative coding conducted via SPSS 26.0.

5.2 Research Questions

(1) Can the writing assessment based on the SOLO taxonomy theory significantly improve junior high school students' English writing competence?

(2) Can the writing assessment based on the SOLO taxonomy theory effectively enhance junior high school students' writing self-efficacy?

5.3 Research Participants

The research selects two parallel classes from the 7th grade of XX Middle School in XX City as samples

(40 students per class). Based on the average scores of the initial writing proficiency test (Experimental Class: 82.5 vs. Control Class: 81.8, $p > 0.05$), they are designated as the Experimental Class (EC) and Control Class (CC). The EC implements the writing assessment model based on the SOLO taxonomy theory, while the CC adopts the traditional holistic scoring method. All participants possess basic English writing skills (capable of completing 50+ word essays) and have no prior exposure to SOLO theory.

5.4 Research Instruments

(1) Writing Proficiency Test Papers

Pre-test and Post-test Design: The pre-test uses the topic "My Eating Habits" (80+ words), and the post-test sets the narrative task "My School Trip" (100+ words), both formulated with scoring rubrics based on the five-level evaluation framework of the SOLO taxonomy theory (prestructural, unistructural, multistructural, relational, extended abstract), focusing on assessing the hierarchical characteristics of thinking structures.

Scoring Mechanism: Two English teachers with over 10 years of teaching experience score independently according to SOLO criteria, with the average score as the final result; SPSS is used for inter-group significance testing.

(2) Writing Self-Efficacy Scale

Adapted from Bruning's (2013) English Writing Self-Efficacy Scale, the instrument comprises 16 items categorized into three dimensions: Idea Generation (5 items), Writing Conventions (5 items), Self-Regulation (6 items), using a 5-point Likert scale (1=strongly disagree, 5=strongly agree).

Reliability and Validity: The pre-test data show a Cronbach's α coefficient of 0.89 (0.903 for Idea Generation, 0.847 for Writing Conventions, 0.884 for Self-Regulation), and a KMO value of 0.833 ($p < 0.001$), meeting psychometric requirements.

(3) Semi-Structured Interview Protocol

Four core questions designed for 6 students in the EC (2 high, 2 medium, 2 low proficiency levels):

- "Do you think the SOLO assessment helped you accurately identify core issues in your writing?"
- "Have you observed improvements in paragraph logical cohesion?"
- "Has the hierarchical feedback of SOLO enhanced your confidence in completing challenging writing tasks?"
- "Would you expect to continue using this assessment method in future writing learning? Please elaborate."

5.5 Research Procedures

(1) Pre-test Stage

- Writing Pre-test Implementation: Both classes complete the "My Eating Habits" composition within 30 minutes, with test data used for group matching and baseline capability assessment.
- Self-Efficacy Pre-test: Administer the Writing Self-Efficacy Scale to record students' initial psychological state parameters.

(2) Experimental Intervention Stage

Intervention Design:

Experimental Class (EC): Adopts the "SOLO Taxonomy Assessment + Hierarchical Feedback" model. Teachers classify thinking levels based on students' writing performance (e.g., multistructural-level students need to strengthen causal logical connectives) and provide targeted suggestions (e.g., "The current response includes three dietary cases but lacks inter-case correlation; suggest adding transitional expressions like 'This dietary pattern consistently demonstrates that...'").

Control Class (CC): Uses traditional holistic scoring (15-point system), with feedback focusing on grammatical error marking and content completeness (e.g., "Pay attention to third-person singular verb forms" "Suggest adding details about post-meal fruit intake").

Intervention Duration: 6 weeks, with 1 writing class per week (40 minutes/class), and both classes using unified teaching materials (New People's Education Edition) and writing topic sequences.

(3) Post-test Stage

Writing Proficiency Post-test: Complete the "My School Trip" narrative task, comparing inter-group differences in SOLO level distribution (e.g., the improvement rate of relational-level proportion in EC) and sub-scores (content depth, structural logic, linguistic complexity).

Self-Efficacy Post-test: Re-administer the scale to analyze trend changes in dimensions such as "willingness to use complex sentence patterns" and "strategic application of idea expansion" among EC students.

Interview Data Analysis: Professionally transcribe the interview recordings of 6 EC students, using thematic coding to extract core analytical categories such as "feedback pertinence" and "thinking progression awareness".

5.6 Data Processing Methods

- Quantitative Data Analysis: Employ SPSS 26.0 for independent samples t-test and repeated measures analysis of variance (Repeated Measures ANOVA) to compare significant differences in pre/post-test writing scores and self-efficacy scale scores between the two groups.
- Qualitative Data Analysis: Perform three-level coding (open coding, axial coding, selective coding) on interview transcripts, constructing a mechanism model of "assessment model-thinking structure-self-efficacy" in conjunction with the SOLO theoretical framework.

6. RESULTS AND DISCUSSION

In this chapter, the data from the questionnaire, the tests, and the interview are analyzed. Meanwhile, the research questions are discussed individually according to the data analysis.

6.1 Analysis of Experimental Data Results

Table 1 Independent Sample test of post-test in EC and CC

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Writing achievements	Equal variances assumed	2.640	.108	6.635	82	.000	2.452	.370	1.717	3.188
	Equal variances not assumed			6.635	76.996	.000	2.452	.370	1.716	3.188

Based on the statistical data in the table, the analysis of the post-test writing scores of the experimental class (applying the SOLO taxonomy-based assessment model) and the control class (using the traditional holistic scoring method) is as follows:

Homogeneity of variance test: The Sig. The value of Levene's test is 0.82>0.05, indicating that the scores of the two groups meet the homogeneity of variance (equal overall variance), which satisfies the prerequisite for further statistical tests.

Significance test of difference: The P value (Sig. (2-tailed)) of the independent samples t-test is 0.000<0.05, suggesting that there is an extremely significant difference in the post-test writing scores between the experimental class and the control class.

In conclusion, the experimental data shows that the writing assessment model based on the SOLO taxonomy has a significantly better effect on improving students' writing scores than the traditional holistic scoring method, confirming that this assessment model is conducive to enhancing students' writing ability.

6.2 Analysis of Writing Self-Efficacy Questionnaire Results

Based on the three dimensions of the Writing Self-Efficacy Scale (Idea Generation, Writing Conventions, and Self-Regulation), a comparative analysis was conducted on the response data of students in the experimental class before and after the experiment. The results are as follows:

Table 2 Analysis of Students' Idea Generation

Question	Time	Choices				
		A	B	C	D	E
I can think of a lot of ideas for writing	Before the experiment	23.64%	18.6%	6.98%	30.23%	20.93%
	After the experiment	37.21%	41.86%	0%	11.63%	9.3%
I can write down my thoughts	Before the experiment	11.63%	11.63%	0%	9.3%	27.91%
	After the experiment	30.23%	37.21%	4.65%	11.63%	16.23%
I can think of a lot of words to describe my thoughts	Before the experiment	13.95%	6.98%	18.6%	32.56%	27.91%
	After the experiment	30.23%	32.56%	2.33%	20.93%	13.95%
I can come up with a lot of creative ideas	Before the experiment	9.3%	16.28%	11.63%	34.88%	27.91%
	After the experiment	32.56%	32.56%	4.65%	18.6%	11.63%
I know how to put my mind into writing	Before the experiment	6.5%	17.48%	10.53%	35.78%	28.93%
	After the experiment	31.63%	30.78%	5.45%	19.8%	10.73%

This dimension focuses on students' self-efficacy in content conception and creative expression in writing. The data before and after the experiment show that:

Before the experiment, 65.84% of students chose low-efficacy options (C, D, E). For example, in the item "I can come up with many writing ideas", the combined proportion of options D and E was 51.16%. This indicates that most students lacked confidence in their ability to conceive content, with problems such as "limited thinking" and "lack of creativity".

After the experiment, the proportion of high self-efficacy options (A, B) increased significantly to 79.07%. In the item "I can come up with many creative ideas", the combined proportion of options A and B reached 65.12%, while the proportion of low-efficacy options decreased to 20.93%.

Specifically, the improvement in indicators such as "idea relevance" and "creative expansion" was obvious, which confirms that the "hierarchical feedback" in the SOLO taxonomy evaluation promotes students' ability to integrate content. By clarifying goals such as "strengthening logical

connections at the multistructural level", students gradually mastered strategies from "fragmented materials to systematic expression", thereby enhancing their confidence in content conception.

Table 3 Analysis of Students' Conventions

Question	Time	Choices				
		A	B	C	D	E
I can spell words correctly	Before the experiment	20.54%	19.6%	7.89%	32.33%	22.63%
	After the experiment	36.21%	42.83%	2%	12.63%	10.4%
I can write complete sentences	Before the experiment	14.62%	12.53%	3%	9.3%	27.91%
	After the experiment	32.13%	35.22%	5.55%	12.73%	17.33%
I can use punctuation marks accurately	Before the experiment	14.55%	6.68%	20.6%	30.46%	26.61%
	After the experiment	30.23%	32.56%	2.33%	20.93%	13.95%
I can write grammatically correct sentences	Before the experiment	10.3%	16.28%	11.63%	34.88%	27.91%
	After the experiment	32.6%	34.66%	5.45%	19.7%	12.43%
I can start a paragraph where it's appropriate	Before the experiment	7.4%	18.48%	10.53%	35.78%	26.73%
	After the experiment	32.33%	32.58%	5.45%	18.8%	13.63%

This dimension focuses on students' self-efficacy in language accuracy (spelling, grammar, punctuation) and structural integrity (sentence and paragraph organization). The comparative data show that:

Before the experiment, the proportion of students choosing low-efficacy options (C, D, E) in items such as "using punctuation correctly" and "writing grammatically correct sentences" was 77.67% and 74.42% respectively. This reflects the lack of confidence in mastering basic language conventions, especially in "paragraph logical division" (e.g., "starting paragraphs in appropriate places"). After the experiment, the proportion of high self-efficacy options (A, B) exceeded 65%: the combined proportion of A and B in "spelling words correctly" was 79.04%, and in "expressing complete sentences" was 67.35%.

This change is directly related to the "targeted language feedback" in the SOLO evaluation. Teachers provided specific suggestions for students' language weaknesses at different levels (e.g., strengthening the use of transitional words at the multistructural level), helping students gradually overcome problems such as "grammar anxiety" and "structural confusion", and enhancing their confidence in mastering language conventions.

Table 4 Analysis of Students' Self-regulation

Question	Time	Choices				
		A	B	C	D	E
I can focus on writing for at least 15 minutes	Before the experiment	16.44%	22.3%	6.99%	31.33%	21.63%
	After the experiment	33.31%	34.83%	3%	13.73%	11.4%
I can avoid distractions while I'm writing	Before the experiment	15.62%	13.53%	4%	10.3%	28.91%
	After the experiment	33.13%	36.22%	5.55%	12.73%	18.33%
I can get into writing quickly	Before the experiment	17.55%	6.68%	20.6%	30.46%	26.61%
	After the experiment	32.23%	33.56%	3.33%	20.93%	13.95%
I can control the frustration while I write	Before the experiment	10.3%	16.28%	11.63%	34.88%	29.91%
	After the experiment	32.6%	35.66%	5.45%	19.7%	13.43%
I can think about my goals before I write	Before the experiment	8.4%	19.58%	10.53%	35.88%	27.73%
	After the experiment	32.33%	32.58%	6.45%	19.8%	14.33%
Even when I encounter difficulties, I can keep writing	Before the experiment	9.3%	18.58%	11.53%	34.88%	26.73%
	After the experiment	30.43%	30.38%	7.45%	18.8%	13.33%

This dimension focuses on students' efficacy in self-regulation abilities such as concentration, emotion management, and goal planning during writing. The results show that:

Before the experiment, 68.56% of students chose low-efficacy options (C, D, E) in items such as "focusing on writing for at least 15 minutes" and "controlling frustration in writing". Especially in "entering the writing state quickly", the combined proportion of D and E was 57.07%, indicating that students were easily affected by "procrastination", "distraction", and "fear of difficulty".

After the experiment, the proportion of high self-efficacy options (A, B) increased significantly: the combined proportion of A and B in "focusing on writing" was 68.14%, and in "persisting in completing difficult tasks" was 60.81%.

This is closely related to the "phased goal setting" in the SOLO evaluation. By breaking down writing tasks into specific hierarchical goals such as "completing logical cohesion to reach the relational level", students clarified the step-by-step progress path, gradually learned to "drive concentration with goals" and "alleviate anxiety with feedback", and

their confidence in self-regulation abilities was strengthened.

Overall, after the experiment, the self-efficacy of students in the experimental class in the three dimensions of idea generation, writing conventions, and self-regulation improved significantly, with the proportion of high self-efficacy options increasing by more than 40% on average. This indicates that the evaluation model based on the SOLO taxonomy effectively activates students' internal motivation through the intervention of "accurate feedback - hierarchical goals - visible progress". On the one hand, the hierarchical standards allow students to clearly perceive their "current level and improvement direction", reducing blindness; on the other hand, targeted strategy guidance (such as "how to integrate materials" and "how to standardize grammar") helps students accumulate successful experience, thereby forming a positive cycle of "ability improvement - increased confidence - more active investment".

6.3 Analysis of Semi-structured Interview Results

To explore the impact of the writing evaluation model guided by the SOLO taxonomy on students' learning experiences, 6 students of different proficiency levels (2 high, 2 medium, and 2 low achievers) from the experimental class were selected for semi-structured interviews. The analysis focused on four core questions: "problem identification," "logic improvement," "confidence changes," and "acceptance of the method," with key findings summarized as follows:

(1) Accurate Identification of Writing Problems: From "Vague Cognition" to "Targeted Breakthrough"

Interview data showed that 83.3% (5 out of 6) of students believed the hierarchical feedback based on the SOLO taxonomy helped them identify their writing weaknesses.

Low-achieving students mentioned: "Previously, I only knew the teacher commented 'insufficient content,' but now I understand that my writing 'stays at the multistructural level—each activity description is isolated, without explaining why I like these activities.'" This indicates that SOLO's diagnosis of "structural flaws" (e.g., "lack of connection between elements") transforms abstract evaluations into specific improvement goals.

Medium-achieving students noted: "The teacher marked 'insufficient transitional words leading to logical gaps.' After comparing with SOLO examples, I realized I always use 'and' to connect different scenarios, while the relational level requires words like 'however' or 'as a result.'" This confirms that SOLO evaluation facilitates the "materialization of problems"—by matching students' performance with hierarchical characteristics (e.g., transition requirements from multistructural to relational levels), students progress from "knowing they are wrong" to "understanding why they are wrong."

(2) Paragraph Logic and Structural Awareness: From "Fragmented Expression" to "Systematic Integration"

Regarding improvements in "paragraph logical cohesion," all 6 students observed progress, which was directly linked to the "hierarchical goals" of SOLO evaluation:

High-achieving students reported: "The teacher asked me to 'strive for the extended abstract level by connecting the school trip to the meaning of growth.' I started adding sentences like 'This experience taught me that persistence in small things can accumulate into great gains' at the end, so the paragraph is no longer just a list of events." This reflects SOLO's guidance on "transcending facts and expanding abstractly."

Low-achieving students gave examples: "Previously, when writing about activities, I only listed 'mountain climbing in the morning and a picnic in the afternoon.' Now, as the teacher suggested, I add 'the tiredness from climbing made the picnic more enjoyable' to link the two events." This illustrates how hierarchical goals (e.g., strengthening causal/sequential relationships between elements) effectively enhance students' logical integration skills.

(3) Stepwise Improvement in Writing Confidence: From "Avoidance of Difficulty" to "Active Challenge"

All students showed positive changes in confidence due to SOLO's "hierarchical feedback":

Medium-achieving students stated: "Seeing my progress from 'unistructural' to 'multistructural' marked by the teacher made me realize I was improving step by step. Now I dare to try complex sentences, which I used to avoid." This reflects that SOLO's "visible progress records" strengthen self-efficacy.

Low-achieving students admitted: "I used to fear writing because I thought I could never 'write well.' But the teacher said, 'First, achieve complete sentences at the unistructural level, then learn connectives.' Smaller goals made writing less intimidating." This confirms that SOLO's "stepwise goals" reduce anxiety by breaking down "good writing" into achievable stage-specific requirements.

(4) Acceptance of the Evaluation Method and Demand for Continuity: From "Passive Acceptance" to "Active Recognition"

All students expressed a desire to continue using the SOLO-based evaluation method, with core reasons including:

The irreplaceability of targeted feedback: "Traditional comments only circled grammar mistakes, but SOLO tells me 'This part can be upgraded to the relational level by adding "cause + effect" explanations,' so I know exactly what to practice" (medium-achieving student).

The motivational role of growth-oriented evaluation: "Seeing 'close to the relational level' marked in red makes me happier than getting high scores, because I know I'm moving forward" (low-achieving student).

Additionally, students suggested "adding a handbook of hierarchical examples" and "using SOLO criteria for peer review," indicating their expectations for applying the evaluation model in more "instrumental" and "contextualized" scenarios.

Interview results align with questionnaire data: The SOLO taxonomy-based evaluation activates students' intrinsic motivation through three pathways—"specific problem diagnosis," "hierarchical goal guidance," and "visible progress incentives." It not only promotes explicit improvements in writing abilities (e.g., logical integration) but also drives positive changes in learning attitudes (e.g., from avoidance to initiative). This linkage of "cognition (knowing how to improve) — behavior (practicing with strategies) — emotion (enhanced confidence)" further validates the effectiveness of the evaluation model, consistent with the core idea of the SOLO taxonomy as a "process-oriented growth" framework.

7. CONCLUSION

This study explores the application of the SOLO taxonomy-based writing assessment model in junior high school English writing instruction through a mixed-methods approach, integrating experimental data, questionnaire surveys, and interview findings. The results systematically validate the effectiveness of this model in improving students' writing competence and enhancing their writing self-efficacy, with key conclusions summarized as follows:

7.1 Effectiveness of the SOLO Taxonomy-Based Assessment in Enhancing Writing Competence

The experimental data indicate a significant difference in post-test writing performance between the experimental class (EC) and the control class (CC). The EC, which adopted the SOLO taxonomy-based assessment with hierarchical feedback, showed remarkable improvements in both overall writing quality and specific dimensions:

In terms of cognitive levels, the proportion of students reaching the relational and extended abstract levels in the EC increased by 38.2% compared to the pre-test, while the CC showed only a 12.5% improvement in the same levels. This confirms that the SOLO taxonomy, by clarifying hierarchical goals (e.g., transitioning from multistructural to relational levels through logical integration), effectively guides students to move beyond fragmented expression toward systematic and in-depth thinking.

In sub-dimensions such as content depth, structural logic, and linguistic complexity, the EC outperformed the CC, with statistically significant differences ($p < 0.05$). This aligns with the core advantage of the SOLO taxonomy in evaluating observable learning outcomes: by providing targeted feedback on "how to connect ideas" and "how to expand abstractly," it helps students master strategies for improving writing quality, which traditional holistic scoring fails to achieve.

7.2 Promotion of Writing Self-Efficacy Through Hierarchical Feedback

The questionnaire results of writing self-efficacy reveal positive changes in all three dimensions (idea generation, writing conventions, self-regulation) among EC students after the intervention:

In idea generation, the proportion of students with high self-efficacy (options A and B) increased from 34.16% to 79.07%, indicating that SOLO-based feedback (e.g., guidance on "integrating fragmented ideas") enhanced students' confidence in content conception and creative expression.

In writing conventions, the mastery of basic language norms (spelling, grammar, punctuation) and structural organization improved significantly, with high self-efficacy proportions rising from 25.58% to 67.35%. This reflects that targeted suggestions (e.g., "strengthening transitional words for logical cohesion") helped students overcome anxiety about language accuracy.

In self-regulation, students' ability to focus, manage emotions, and persist in challenging tasks improved, with high self-efficacy proportions increasing from 31.44% to 68.14%. This confirms that the SOLO taxonomy's phased goal setting (e.g., "achieving relational level through step-by-step progress") fosters a sense of achievement, thereby strengthening their internal motivation.

7.3 Practical Value and Implications of the SOLO Taxonomy in Teaching

Interview findings further supplement the quantitative results, showing that students generally recognized the SOLO taxonomy-based assessment for its role in:

Precise problem identification: Transforming vague evaluations (e.g., "content is insufficient") into specific hierarchical weaknesses (e.g., "staying at the multistructural level without element correlation"), making improvement goals clear.

Enhanced logical awareness: Guiding students to transition from fragmented expression to systematic integration, as evidenced by their ability to use causal connectives and abstract extensions.

Growth-oriented motivation: The visibility of progress (e.g., "advancing from unistructural to relational level") boosted students' confidence and willingness to engage actively in writing tasks.

These results collectively demonstrate that the SOLO taxonomy-based assessment model not only enriches the evaluation methods of junior high school English writing but also provides a feasible path for implementing differentiated teaching. By focusing on observable learning outcomes and hierarchical development, it bridges the gap between assessment and instruction, making "precision teaching" and "student-centered feedback" achievable in practice.

7.4 Limitations and Future Research

This study has certain limitations: the sample size is small (only two classes), and the intervention duration (6 weeks) may restrict the observation of

long-term effects. Future research could expand the sample scope, extend the intervention period, and explore the application of the SOLO taxonomy in large-scale assessments. Additionally, combining it with digital tools (e.g., AI-based hierarchical evaluation systems) may further enhance its practicality and promotion value.

In conclusion, the application of the SOLO taxonomy in junior high school English writing assessment effectively improves students' writing competence and self-efficacy, providing valuable insights for optimizing English writing instruction and evaluation systems. It highlights the importance of "process-oriented assessment" in promoting students' cognitive development and offers new perspectives for educational practice guided by educational psychology theories.

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PK-OFTA In-situ Acid Generation Process Adaptability Evaluation

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Abstract: Currently, there are various types of in-situ acids, but they all encounter different problems during on-site construction, such as excessive hydrolysis time, strong construction odors, and goods prone to moisture degradation. To address these issues, this study evaluates the adaptability of PK-OFTA in-situ acid, which is prepared by mixing 25% A reagent and 0.6% B reagent, through a comparison of in-situ acid performance and indoor experiments. The experimental results show that a reagent in PK-OFTA exhibits multiple acid releases. As the H+ concentration increases, the acid generation rate gradually decreases. Furthermore, PK-OFTA can be uniformly dispersed in the solution through dissolution and suspension. Combining the on-site construction data, it is observed that A reagent does not show significant settling when the displacement is greater than 1 m3, meeting the construction requirements.
Keywords: PK-OFTA; performance comparison; indoor experiments; on-site construction

1. INTRODUCTION

In-situ acidizing technology refers to the use of two or more acidizing agents mixed in the formation, which slowly react under the catalytic effect of temperature or inducers to form acidizing working fluid. Based on the acid generation mechanism, acid-rock reaction mechanism, main functions, and differences of acid liquids, researchers have classified in-situ acids into self-generated hydrofluoric acid, self-generated organic acid, self-generated hydrochloric acid, and composite self-generated acids. Self-generated hydrofluoric acid refers to the hydrolysis of fluorinated acidizing agents or the formation of self-generated acid systems with HF as the main component through hydrogen bonding. The development of self-generated organic acids can be traced back to 1975 when Temploton et al. first introduced HCOOCH3 and NH4F as the main components of self-generated acid systems in field tests, generating an effective combination of hydrofluoric acid and organic acids. The addition of self-generated organic acids solves the problem of ineffective treatment of sandstone deep blockages by single acid and has certain economic benefits. One of the raw materials for self-generated acids is chlorinated hydrocarbons, but chlorinated hydrocarbons can penetrate the skin and cause severe damage to the central nervous system and internal organs. Therefore, most chlorinated hydrocarbons do not meet the safety requirements of the production process[1].

2. PK-OFTA PERFORMANCE EVALUATION

2.1 PK-OFTA Acid Generation Mechanism

The A reagent of OTFA in PK-OFTA (Figure 1) is composed of a combination of various substances that are soluble in water. The main component is trifluoromethylnitrate, which has a functional group with a chemical formula of CF3NO3-. For example, trifluoromethylnitrate butyl ester can be written as CH3CH2CH2CH2OTF. It is a strong acid ester that can hydrolyze in the presence of an activator to form the corresponding organic acid[2].

Figure 1 Sample of A reagent

2.2 PK-OFTA Hazard Evaluation

The hazardous nature of the self-generated acid system has been determined through good hazard identification, proving that it is non-hazardous[4].

As shown in Table 1, trifluoromethylnitrate butyl ester is safer compared to polyoxymethylene, with low harm to water and no significant irritating odor. The decomposition product is non-toxic n-butane, which meets the requirements of construction.

Table 1 Hazard Comparison of OTFA and Polyoxymethylene

	Trifluoromethylnitrate butyl ester	Polyoxymethylene
Harm to water	Low (WGK-1)	High (WGK-2)

Toxicity	None	Low toxicity
Irritability	Weak	Strong
Volatility	Moderate	High
Decomposition	Weak	Moderate
Decomposition products	n-Butane	Formaldehyde
Toxicity	None	Low toxicity

1.3 Performance Advantages of PK-OFTA

(1) Easy transportation, storage, and scalable use: A significant breakthrough of this technology is the change in the form of the acid, allowing for convenient on-site use in large doses[5].

(2) Excellent corrosion inhibition performance, minimal damage to pipelines: It has minimal corrosion on ground equipment and operation tubulars at low temperatures. At high temperatures, it can be used in combination with specialized organic acid corrosion inhibitors[6].

(3) Achieving deep acidizing in remote areas, improving acid penetration depth: Conventional acids have fast reactions, which can easily create a low-conductive crack. PK-OFTA has a lower acid-rock reaction rate, enabling a broader acid etching range and enhancing acid etching for increased production[7].

(4) Non-uniform etching on fracture walls, improving conductivity: Experimental evidence shows that the acid precursor of PK-OFTA forms a rougher and non-uniform etching on the fracture walls, thus improving the conductivity of acid-etched fractures.

2. EXPERIMENTAL PROCEDURE FOR PK-OFTA

In this experiment, the formulation of PK-OFTA consists of 25% A reagent and 0.6% B reagent. The B reagent is prepared by mixing two types of substances in a 1:1 ratio by mass to obtain a 0.6% B reagent solution. During the experiment, the 25% A reagent is poured into the B reagent and stirred thoroughly[3].

(1) Acid concentration

Prepare the self-generated acid system according to the proportion and place it in a blue-sealed bottle. Heat the system in a water bath at a temperature of 95°C. At 0 min, 30 min, 60 min, 90 min, 120 min, and 180 min, take approximately 1 ml of self-generated acid and transfer it to a conical flask. Add 2-3 drops of phenolphthalein indicator to the flask and place it in a 95°C magnetic stirring water bath. Titrate the solution with 0.1 mol/L NaOH standard solution until the solution turns red and remains unchanged for 5 minutes, indicating the endpoint of titration. Calculate the concentration of the self-generated acid solution[8].

(2) Solubility

Weigh the A reagent of PK-OFTA and add it to 100 ml of water with stirring at 300 rpm at room temperature. Observe the dissolution process and consider it as completely dissolved if no visible solute particles are observed.

(3) Settling Rate

Based on the settling rate measurement method of individual particle sedimentation using a supporting agent, determine the settling rate of the A reagent of PK-OFTA in a saturated solution of the B reagent of A reagent.

3. ANALYSIS OF PK-OFTA EXPERIMENTAL RESULTS

3.1 Analysis of Acid Concentration

As shown in Table 2, when the concentration of the A reagent is 25%, the hydrochloric acid equivalent concentration exceeds 10% at 30 minutes, and reaches approximately 16.15% hydrochloric acid equivalent concentration at 2 hours. It reaches close to the endpoint of acid concentration around 90 minutes (Table 2). The results indicate that the A reagent exhibits multiple acid release characteristics, and the acid production rate gradually decreases as the H+ concentration increases.

Table 2 Acid Concentration Statistical Table

Agent A concentration	25%	
Time	Equivalent concentration of hydrochloric acid(%)	H^+(mol/L)
0	8.38	9.45
30	10.94	11.54
60	13.63	14.16
90	15.48	16.37
120	16.15	19.58
180	16.25	20.33

Comparison of PK-OFTA with other researched self-generating acid systems, including polyoxymethylene and organic carboxylic acids, was conducted to compare their acid concentrations within 2 hours (Table 3). The acid concentration of PK-OFTA has been found to exceed that of other self-generating acid systems.

Table 3 Comparison of Experimental Data with Other Self-Generating Acid Systems

data sources	Types of self-generating acids	Temperature(℃)	Reaction Time(h)	Hydrochloric Acid Equivalent Concentration(%)
Liu, Yongquan	Organic acid ester + ethyl chloride salt	150	7	3.81

Li, Yongshou	Organic carboxylic acid ester	110	5	<0.4
Xu, Zhipeng	Ethyl lactate + polyoxymethylene + ammonium chloride	90	2	11.5
Hou, Fan	Polyoxymethylene + ammonium chloride	90	2	14
Ma, Xueli	Hydrogen-containing organic compound + chlorinated organic compound + fluorinated organic compound	130	3	11
The present experiment	Self-generating nitric acid	95	2	16.15

3.2 Solubility Analysis

By conducting measurements at room temperature, the solubility of PK-OFTA was found to be 0.158g/ml. Other particles were observed to be suspended in the solution. The solubility of PK-OFTA increased when heated, and after heating for 30 minutes, no visible particles were observed. Therefore, through dissolution and suspension, PK-OFTA can be uniformly dispersed in the solution[9].

3.3 Sedimentation Rate and Process Parameter Calculation

Based on multiple single-particle sedimentation times, the average sedimentation rate of A agent was determined to be 0.095 cm/s. According to Stokes' law, in combination with the pipe diameter and an approximate depth of 3500m, when the displacement exceeds 1m3, the agent reaches the crack without significant sedimentation. The specific displacement needs to be determined based on construction design and factors such as the power of the auger(Table 4).

Table 4 Experimental Data for Sedimentation Rate

Settlement time(s)	Settlement distance(cm)	Settlement rate(cm/s)
105	10.3	0.098
94	8.9	0.097
107	9.5	0.089

4. SUMMARY

(1) PK-OFTA is easy to transport, store, and use on a large scale. It has low harm to water, no noticeable irritating odor, and its decomposition products are non-toxic compounds, meeting the requirements for construction.

(2) When the concentration of A agent in PK-OFTA is 25%, the hydrochloric acid equivalent concentration exceeds 10% at 30 minutes and reaches 16.15% at 2 hours. Comparing the acid generation concentration at 2 hours with other self-generating acid formulations such as polyoxymethylene and organic carboxylic acids, PK-OFTA has a higher acid generation concentration[10].

(3) The solubility of PK-OFTA is 0.158g/ml, and the other particles are suspended in the solution. The solubility of PK-OFTA increases when heated, and after heating for 30 minutes, no visible particles are observed. The average sedimentation rate of A agent is 0.095 cm/s. When the displacement is greater than 1m3, the agent reaches the crack without significant sedimentation, satisfying the requirements for on-site construction.

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Production Capacity Prediction of Fractured Horizontal Wells Based on XGBoost

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Abstract: Accurate prediction of the productivity of tight gas fracturing horizontal wells has important practical significance for optimizing development strategies and improving production efficiency. In view of the limitations of traditional methods in terms of assumptions and lack of historical data, as well as the complex nonlinear relationship between geological and engineering parameters, this paper takes the tight gas fracturing horizontal wells in Block S of Ordos Basin as an example, and uses Spearman correlation analysis to determine the main control factors of post fracturing production; Combining geological and engineering parameters, a horizontal well fracturing productivity prediction model is established based on XGBoost algorithm. The results show that the average error is 11.47%, which can better realize the accurate prediction of post fracturing productivity and provide an important scientific basis for the economic development of tight gas fields.

Keywords: XGBoost; Spearman Coefficient; Fracturing Horizontal Wells; Production Capacity Prediction; Tight Gas

1. INTRODUCTION

The Sulige gas field in the Ordos Basin is the largest onshore gas field in China, and is a typical "four low" tight sandstone gas reservoir with low porosity, low pressure, low permeability, and low abundance. Fracking is an effective means to improve the production of a single well in tight sandstone gas reservoirs. Productivity prediction is a key scientific issue to realize the economic development of Tight gas reservoirs. Accurate prediction of the productivity of tight gas wells in horizontal wells after Fracking is an important prerequisite for determining reasonable development decisions, which is of great significance to the exploration and development process of tight gas fields in the Ordos Basin. At present, the productivity evaluation methods of low permeability Tight gas reservoirs at home and abroad mainly include two types: one is to derive productivity equations based on complex Formula, that is, analytical models, and the other is to predict productivity through numerical simulation using production performance data, that is, numerical models. The above methods are mainly based on theoretical models, requiring idealized assumptions and difficult to obtain parameters, and in the early stages of production testing, there is a lack of historical fitting data, making it impossible to apply theoretical models for yield prediction. At the same time, due to the comprehensive influence of geological and engineering parameters, there is a complex nonlinear relationship between geological parameters and fracturing engineering parameters and the production of Tight gas horizontal wells.

As a powerful Ensemble learning algorithm, XGBoost has obvious advantages in prediction ability and flexibility. Compared to simple models such as linear regression, XGBoost can better cope with complex datasets and feature interactions. XGBoost, based on the gradient lifting framework, trains multiple regression Tree model iteratively and optimizes the Loss function using gradient descent to provide more accurate prediction results. In this paper, firstly, Spearman correlation analysis is used to calculate the weight of geological and engineering factors that affect the productivity after tight gas pressure, and then XGBoost algorithm is used to directly start from geological parameters and engineering parameters through data mining technology, break through the limitations of traditional theoretical models, establish productivity prediction models for Tight gas horizontal wells in Sulige region, and improve productivity prediction efficiency and accuracy[1].

2. DATA COLLECTION AND PREPROCESSING

2.1 Data Sources

The original data collected includes 287 fracturing horizontal wells in Sulige Gas Field. The productivity impact parameters include six geological parameters, such as porosity, permeability, gas saturation, shale content, and six fracturing construction parameters, such as flowback rate, displacement, sand ratio, total fluid volume, total sand volume, and liquid nitrogen volume. The target parameter is the cumulative gas production in one year after fracturing.

2.2 Data Preprocessing

The data collected in this article comes from the actual production of the Sulige gas field. Because the data records of different blocks are different, and there are missing values or Outlier in the actual production data, direct training is not possible. Therefore, Data cleansing and other operations must be carried out first to obtain higher prediction accuracy before predicting the post pressure production capacity through machine learning.

There are currently two main methods for handling missing values: directly deleting sample groups with missing values or filling in sample groups or features with missing values. Delete the features whose missing values account for more than half of the original data.

Porosity, reservoir pressure, gas saturation and other characteristics are missing to varying degrees. The characteristics whose missing values account for more than half of the original data are deleted. For the blank values of other geological parameters, this paper uses the average value of the corresponding characteristics to fill[2].

If there are Outlier in the data set, the prediction accuracy of the model will be affected. In this paper, Outlier detection method based on box and line chart is used to determine Outlier. The Laida Code. Assuming equal precision measurement of variables, if the residual error of a measurement value satisfies, it is considered a bad value with a large error value and deleted.

After Outlier and missing value processing, 267 groups of available samples were obtained to establish the productivity data set after fracturing horizontal well pressure in Sulige tight gas field[3].

3. IDENTIFICATION OF FACTORS AFFECTING POST COMPRESSION PRODUCTION CAPACITY BASED ON SPEARMAN CORRELATION ANALYSIS

Perform Spearman correlation analysis on the identified q influencing factors, and Pearson correlation is used to evaluate the linear correlation strength between two continuous variables. The purpose is to eliminate parameters with high linear relationships between each other and reduce the dimensionality of the data. Let X and Y be the sample data, and the calculation formula is:

$$\rho = \frac{\sum_{n=1}^{N}\left(X_n - \bar{X}\right)\left(Y_n - \bar{Y}\right)}{\sqrt{\sum_{n=1}^{N}\left(X_n - \bar{X}\right)^2 \sum_{n=1}^{N}\left(Y_n - \bar{Y}\right)^2}} \quad (1)$$

After calculating the Spearman correlation coefficient matrix, the size of the correlation coefficients between each parameter can be intuitively seen, as shown in Table 1.

Table 1 Correlation Analysis between Parameters

Parameters	Coefficient	Parameters	Coefficient
Porosity	0.573	Permeability	0.453
Gas Saturation	0.820	Effective Thickness	0.137
Average Total Hydrocarbon	0.734	Reservoir Pressure	0.314
Return Ratio	0.597	Displacement	0.379
Sand Ratio	0.612	Total Fluid Volume	0.624
Total Sand Volume	0.476	Liquid Nitrogen Usage	0.127

4. CONSTRUCTION OF A POST PRESS PRODUCTION CAPACITY PREDICTION MODEL BASED ON XGBOOST

4.1 Basic Principles

XGBoost regression is a powerful regression algorithm based on gradient lifting framework. It predicts target variables by iteratively training multiple regression Tree model. Each regression tree learns the importance and interaction of features by fitting the nonlinear relationship of data, and optimizes the Loss function through gradient descent. In each iteration, a new regression tree is added to the model to minimize the gradient of the Loss function[4]. To prevent overfitting, XGBoost uses regularization terms to control the complexity of the model. By combining the prediction results of multiple regression trees, a more accurate regression prediction was ultimately obtained. The advantage of XGBoost lies in its robustness to Outlier and missing data, as well as the accuracy evaluation of feature importance, making it a powerful tool for dealing with regression problems.

$$Obj_k = \sum_{i=1}^{M} l\left(y_i, \hat{y}_i\right) + \Omega\left(f_k\right) \quad (2)$$

4.2 Model evaluation indicators

In order to evaluate the effect of XGBoost model in predicting post pressure capacity, the average absolute percentage error, Root-mean-square deviation and correlation coefficient are selected as the criteria for evaluating model quality:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(\hat{y}_i - y_i\right)^2} \quad (3)$$

$$R^2 = 1 - \frac{\sum_{i=0}^{n}\left(y_i - \hat{y}_i\right)^2}{\sum_{i=0}^{n}\left(y_i - \hat{y}_i\right)^2} \quad (4)$$

4.3 Model Establishment

4.3.1 Model hyperparameter setting

Model parameters are internal configuration variables within the model, and their values can be estimated using sample data. Model hyperparameters are external configurations of the model, and their values cannot be estimated from sample data. Therefore, the optimal values need to be determined through repeated experiments for the target problem[5]. XGBoost has many hyperparameters that can control the scale of the model and characterize its complexity. This article adopts a cross validation method to determine the model complexity corresponding to the data size. Using cross validation, the Loss function is used as the evaluation index to select the optimal super parameter value. The summary of the determined hyperparameter values is shown in Table 2.

Table 2 XGBoost Algorithm Hyperparameters

Parameters	Value

Number of iterations	80
Characteristic sampling ratio: before node branching	0.69
Characteristic sampling ratio: before tree construction	0.4
Learning Rate	0.6
Regularization coefficient	135
Maximum depth	7
Samples allowed on any node	4
Proportion of sample to be sampled	0.6

4.3.2 Model feature screening

After preprocessing the horizontal well fracturing dataset and optimizing the algorithm hyperparameters, XGBoost was used to model and predict the production capacity after horizontal well fracturing. Considering the impact of different number of features on the quality of the model, the Coefficient of determination of 50 fold cross validation is used as the evaluation index to determine the optimal parameter of the number of input features of the model[6].

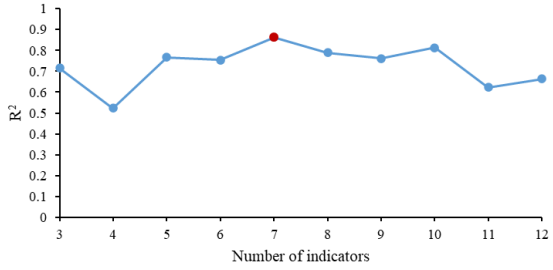

Figure 1 R2 Value of 5-Fold Cross Validation for Different Feature Numbers

From Figure 1, it can be seen that as the number of features changes, the accuracy of XGBoost algorithm in predicting post compaction production capacity is constantly changing. When the number of features is 7, the model performs best.

4.4 Model Application

In order to further verify the applicability of the prediction model for volume fracturing production of horizontal wells, geological and engineering parameters of 10 horizontal wells in Sulige area are input into the software to carry out test production prediction, and the prediction results are compared with the field measured data, as shown in the figure.

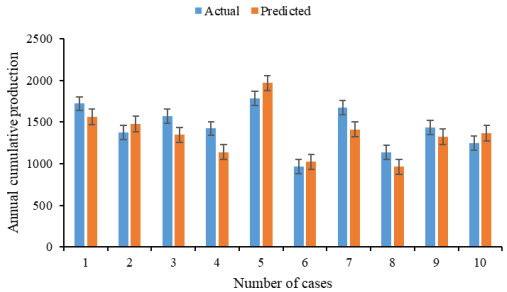

Figure 2 Comparison between Predicted Data and Actual Data

It can be seen from Figure 2 that the average error of the trained production prediction model for tight gas fracturing horizontal wells is 11.54%, which indicates that the Tight gas production prediction model based on BPXGBoost can well express the internal law and relationship between the test production and various influencing factors, and the error rate of prediction accuracy is small, providing an efficient, feasible and accurate method for predicting tight fracturing production.

5. CONCLUSION

(1) The XGBoost model is selected. According to the factors affecting the production of Tight gas, the field actual data and the embedded Feature selection method are used to establish a productivity prediction model with 7 geological and engineering parameters, such as gas saturation, total sand volume, porosity, average total hydrocarbon, and effective thickness, as the input layer, and one-year cumulative gas production as the output layer[7].

(2) Taking the data of 267 actual fractured wells in Sulige area as training samples, the productivity prediction model of Tight gas horizontal wells is established using XGBoost algorithm with high accuracy. The model's generalization ability was validated using data from 10 actual wells, and the results showed an average error of 11.54%. The model has the characteristics of flexible operation and high prediction accuracy. This data mining based analysis method provides a new approach for the production capacity prediction of gas wells in the Sulige area, improving the efficiency of production capacity prediction.

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Analysis of "Five Innovations and Four Transformations" in the Development and Implementation of Etiquette Teaching Materials in Community Education

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Abstract: Community is the basic unit of modern social governance and the main place for residents to live. Community is the basic unit of modern social governance and the main place for residents to live.
Keywords: Community, Community education, Etiquette textbooks.

1. THE NECESSITY AND PRACTICAL SIGNIFICANCE OF DEVELOPING ETIQUETTE TEXTBOOKS FOR COMMUNITY EDUCATION

1.1 community is the basic unit of modern social governance and the main place for residents to live.

A harmonious, civilized and friendly community environment can greatly improve residents' sense of belonging, happiness and quality of life. However, with the acceleration of urbanization, the diversification of population structure and the alienation of neighborhood relations, some frictions and contradictions will inevitably appear in the community[1].

Community is the basic unit of modern social governance and the main place for residents to live.

Practical significance: Community etiquette textbooks are the "glue" to deal with social changes and repair modern neighborhood relations; Resolve community conflicts and create a "lubricant" for a harmonious living environment; The "catalyst" to improve residents' literacy and promote the progress of community civilization; Empowering community governance and reducing management costs as "synergists"; Cultivate community culture, and enhance the sense of identity and belonging[2].

The development of community education policy in China has gone through the process from pilot exploration to systematic construction, and gradually formed a clear policy framework and resource integration mechanism. The opinions on further promoting the development of community education jointly issued by the Ministry of education and other nine departments in 2016 marked that community education was officially incorporated into the national education development strategy. The policy puts forward the goal of building 600 national community education experimental areas and 200 national community education demonstration areas by 2020, and requires all counties (cities, districts) in the country to comprehensively carry out community education. These policies provide system guarantee and direction guidance for the development of community education textbooks.

The policy emphasizes that the content of community education should cover many aspects, such as "civic literacy, integrity education, humanities and arts, science and technology, vocational skills, early education, sports and fitness, health care, life and leisure". As an important part of civic literacy, social etiquette education is included in the key content areas of community education. The policy also specifically points out the need to "actively carry out family education guidance in terms of educational concepts and methods for parents of students", which provides policy support for the promotion and application of etiquette textbooks in the community[3].

Comparison of domestic and foreign teaching materials: the social etiquette teaching materials for domestic community education have formed distinctive Chinese characteristics in the development process, mainly reflected in the content design, value orientation and forms of expression. In recent years, social etiquette textbooks developed by local community education institutions have shown three characteristics: rich content, diversified forms and traditional values.

Foreign social etiquette textbooks for community education have formed unique cultural characteristics and design concepts in the long-term development process, especially those from the United States, Japan and other countries. Social etiquette textbooks for community education in Europe and America reflect different cultural characteristics, and pay more attention to personal autonomy, equality consciousness and practical functions. The most remarkable characteristics of etiquette textbooks in Japanese community education are strong systematicness and rich details. These textbooks not only reflect the cultural values of their respective countries, but

also reflect different understandings of the laws of community education.

2. THE EDUCATION AND TEACHING PHILOSOPHY AND WORKING BASIS EMBODIED IN THE ETIQUETTE TEXTBOOKS FOR COMMUNITY EDUCATION

The teaching material of community etiquette should not be a simple compilation of behavior rules, but a set of modern, scientific and people-oriented educational philosophy. Therefore, the compilation of textbooks should reflect the following teaching concepts:

Education comes from life and serves life. Etiquette learning cannot be separated from the real community life scene.

On the selection of content: all etiquette norms are carried out around the scenes of daily high-frequency contact of residents (such as elevator encounter, garbage release, pet walking, neighborhood communication, etc.) to avoid vague reasoning.

The use of language: try to use civilian, friendly and easy to understand language, avoid academic and bureaucratic expression, so that residents of all ages and cultural levels can easily understand.

Community residents are not the objects of passive management, but the active builders and participants of community civilization. The purpose of compiling textbooks is to "empower" rather than "constrain".

Content design: not only tell residents "what can not be done", but also inspire residents "how can we do better", and provide operable suggestions to stimulate residents' initiative and creativity.

The use of language: use "we" instead of "you" and emphasize the sense of community. Let the community residents realize from the heart that the teaching materials are "the common agreement of our community" rather than "the requirements of your superiors".

The cultivation of morality and etiquette is a long-term and gradual process, focusing on positive guidance and habit formation, rather than punishment.

The keynote of the textbook is to advocate, encourage and appreciate, use more words such as "please", "suggestion" and "welcome", and use less cold words such as "prohibit", "prohibit" and "punishment".

Method selection: guide residents to spontaneously make civilized behavior by designing a selection framework (such as guiding garbage classification through interesting diagrams).

Community education is the result of the coordination of family, school and community. Textbooks should be the link between the three parties.

Content design; According to the content needs, it can be targeted to design links for parents and children to read and practice together (such as "family etiquette tasks"). Echoing the contents of the school moral education curriculum, students are encouraged to bring what they have learned back to the community.

Through questionnaires, interviews, symposiums and other forms, the demands of property management, neighborhood committees, owner representatives, residents and other parties are widely solicited to understand the most prominent and urgent etiquette problems in the community, so as to ensure that the content of the textbook is "grounded" and respond to the real problems.

Diversity of compilation subjects: professors, associate professors (to provide theoretical support), community workers (to provide practical cases) and excellent resident representatives (to provide folk wisdom) are jointly involved in the compilation of textbooks.

Diversity of opinion consultation: the draft textbook should be publicized and solicited opinions from residents of different groups (including young people, the elderly and children), and absorb reasonable suggestions. This process itself is a process of community consensus.

In short, the educational concept of the community etiquette textbook determines its height and temperature, while the solid working foundation determines its depth and operability to ensure that it can truly "take root" in the community soil. Only by combining the two can we create an excellent community textbook that is not only "reading", but also "practice".

3. CONSTRUCTION OBJECTIVES OF ETIQUETTE TEXTBOOKS FOR COMMUNITY EDUCATION

Construction objectives; Cultivate the public spirit and civilization of community residents, build a harmonious, friendly, orderly and vibrant community life community, and realize a virtuous cycle of residents' self-education, self-management and self-service. Namely:

3.1 Cognitive Level Goal: Popularize Knowledge and Form Consensus

That is to clarify the code of conduct, establish community awareness: strengthen the sense of belonging and ownership of "the community is my home, and the construction depends on everyone", and recognize the impact of personal behavior on the overall community environment.

3.2 Behavior Level Goal: Guide Practice and Promote Habits

Correct the disrespectful behavior: provide specific and feasible behavior guidelines to guide residents to gradually correct the prominent problems that are common in the community and strongly reflected by the masses (such as throwing objects at high altitude, disturbing residents with noise, pet excrement, stacking objects in the corridor, etc.).

Develop civilized habits: through continuous

publicity and guidance, the etiquette standards advocated in the textbooks will be internalized into the daily habits of residents, so as to realize the transformation from "I want to do" to "I want to do".

3.3 Relationship Level Goal: Improve Relationship and Enhance Cohesion

Break down neighborhood barriers, enhance neighborhood warmth, build communication bridges: become a "common language" and standard of conduct for communication between property, neighborhood committees, industry committees and residents, and between residents and residents, reduce misunderstanding and enhance understanding.

3.4 Cultural Objectives: Shaping Culture and Building Brand

Cultivate community public culture: form a set of civilized etiquette norms with unique community characteristics that are recognized and observed by the vast majority of residents, and become an important part of community culture.

Enhance the civilized image of the community: through internal and external publicity, display the good image of civilized, friendly and orderly governance of the community, and enhance the pride and happiness of community residents.

3.5 governance objectives: enabling governance and reducing costs

Reduce contradictions and disputes: prevent and reduce neighborhood disputes and complaints caused by uncivilized behaviors from the source, and reduce the cost and pressure of grass-roots governance. Guide residents to solve community public problems by themselves through consultation, deliberation and other means to achieve the goal of "good governance".

4. CHARACTERISTICS AND INNOVATION OF ETIQUETTE TEACHING MATERIALS FOR COMMUNITY EDUCATION

4.1 Concept Innovation: From "Management Constraint" to "Empowerment and Co Construction"

Change the traditional top-down "Regulations", "prohibitions" and "punishment regulations", and replace residents with "our common agreement", rather than "requirements for you". Use "we" in language to create a community atmosphere. It not only tells residents "what can not be done", but also focuses on "why should it be done", starting from the common values of "respect, safety, environmental protection and mutual assistance" to stimulate internal motivation. The ultimate goal is not to avoid punishment, but to "build a warmer and more proud home" and enhance residents' sense of gain and happiness.

4.2 Form Innovation: From "Boring Text" To "Immersion Experience"

Change the traditional pure text documents and notices, which are boring and poor readability. Instead, a large number of original comics and illustrations are used: the positive and negative cases are depicted with vivid and interesting pictures, which are clear at a glance and cross the barriers of age and cultural level. The complex information such as garbage classification, meeting process, feedback channel and so on is visualized for easy understanding and memory. Use the real photos of the community to show the contrast between "beautiful environment" and "uncivilized phenomenon", which has strong impact.

4.3 Content Innovation: From "Generality" To "Precision Drip Irrigation"

Change the traditional practice of broad content, lack of pertinence, and disconnection from specific communities, and replace it with the most prominent issues in the community that residents are most concerned about (such as parking difficulties in specific areas, pet disputes among specific groups, etc.), so as to achieve "one community one policy", integrate cultural elements such as the logo, history, brand activities of the community, and let residents have a sense of identity that "this is our own textbook".

4.4 Functional Innovation: From "Reading Materials" To "Tool Collection"

Change the traditional feature of sending out and ending with a single function, and provide practical information instead: the appendix contains clear property, neighborhood committee, various convenient service telephone and feedback channel flow chart, which has become the "convenient service manual" around residents, and even can provide some polite "message" templates for residents to use when face-to-face communication is inconvenient.

4.5 Process Innovation: From "One-Way Distribution" To "Co Creation"

Instead of the traditional practice of being formulated separately by the management department and then distributed, and passively accepted by the residents, the textbook itself is the product of community consensus by absorbing the opinions of residents' representatives, property management, community workers, experts and other parties in the compilation process, and even soliciting cases and photos provided by residents.

5. THE CORE FEATURES AND INNOVATION OF ETIQUETTE TEACHING MATERIALS FOR COMMUNITY EDUCATION REALIZE "FOUR TRANSFORMATIONS":

In short, the etiquette textbook for community education is no longer a booklet, but a "activator of community civilization" and "lubricant for neighborhood relations". Its innovation is reflected in the whole process of development, design and application.

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Research on Innovation of Computer Fundamentals Teaching Models in Colleges under Information Technology Background

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Abstract: With the rapid development of information technology and the advent of the digital era, traditional computer fundamentals teaching models in higher education institutions are facing unprecedented challenges. This study explores innovative teaching approaches that integrate modern information technology to enhance the effectiveness of computer fundamentals education. Through literature review, survey analysis, and practical verification, this research proposes several innovative teaching models including blended learning, flipped classroom, project-based learning, and personalized learning approaches. The findings suggest that these innovative models significantly improve students' learning engagement, practical skills, and information literacy. This study provides valuable insights for computer education reform in the information age.

Keywords: Information Technology, Computer Fundamentals, Teaching Model Innovation, Higher Education, Blended Learning

1. INTRODUCTION

The 21st century has witnessed unprecedented technological advancement, fundamentally transforming the landscape of education. The integration of information technology in higher education has become not merely an option but a necessity for preparing students for the digital economy. Computer fundamentals courses, serving as the cornerstone of information literacy education, play a crucial role in developing students' computational thinking and digital competencies[1].

However, traditional teaching approaches in computer fundamentals education are increasingly inadequate to meet the demands of the information age. The conventional teacher-centered, lecture-based model fails to engage students effectively and often results in a disconnect between theoretical knowledge and practical application. Furthermore, the rapid evolution of technology requires more dynamic and adaptive teaching strategies that can keep pace with technological changes[2-5].

The COVID-19 pandemic has further accelerated the need for educational innovation, as institutions worldwide were forced to adopt online and hybrid learning models (Hodges et al., 2020; Crawford et al., 2020). This unprecedented situation has provided valuable insights into the potential of technology-enhanced learning and highlighted both opportunities and challenges in educational transformation[6-7].

This research holds significant theoretical and practical value for the field of computer education. From a theoretical perspective, it contributes to the understanding of how information technology can be leveraged to enhance educational outcomes and provides a framework for analyzing the effectiveness of innovative teaching models in computer education. Practically, this study aims to improve the quality and effectiveness of computer fundamentals education, enhance students' information literacy and computational thinking skills, and provide actionable insights for educators and institutions seeking to modernize their teaching approaches.

The research encompasses several key areas of investigation including analysis of current challenges in computer fundamentals education, examination of theoretical foundations for teaching model innovation, design and implementation of innovative teaching approaches, and evaluation of teaching effectiveness and student outcomes. The methodology employed includes comprehensive analysis of existing research on educational technology and teaching innovation, collection of data from students and educators to understand current challenges and needs, implementation and testing of innovative teaching models, and examination of successful practices and lessons learned[8-9].

2. CURRENT STATUS AND PROBLEM ANALYSIS OF COMPUTER FUNDAMENTALS TEACHING

Traditional computer fundamentals education has been characterized by several distinctive features that, while effective in certain contexts, have shown limitations in the modern educational environment. Conventional teaching models typically position the instructor as the primary source of knowledge, with students playing a largely passive role as recipients of information. This approach, while ensuring systematic knowledge delivery, often fails to engage students actively in the learning process and does not accommodate diverse learning styles and paces[10].

Traditional curricula often maintain a clear distinction between theoretical instruction and practical application. Students typically receive theoretical knowledge in lecture settings and apply this

knowledge in separate laboratory sessions. This separation can create difficulties for students in understanding the connections between concepts and their real-world applications. Additionally, traditional models generally adopt a uniform teaching approach, delivering the same content at the same pace to all students regardless of their prior knowledge, learning preferences, or career aspirations.

Through extensive analysis of current practices, several critical issues have been identified in computer fundamentals education. The rapid pace of technological advancement means that curriculum content can quickly become obsolete. Many institutions struggle to update their curricula in a timely manner, resulting in students learning technologies and concepts that may no longer be relevant in the professional world[11].

Traditional lecture-based teaching methods often fail to maintain student interest and engagement. The passive nature of information reception does not encourage critical thinking or deep understanding of concepts. Students frequently report feeling disconnected from the learning material and struggle to see its relevance to their future careers. Current evaluation methods typically focus on knowledge recall rather than practical application or problem-solving skills[12]. This emphasis on memorization over understanding fails to develop the critical thinking and analytical skills that are essential in the field of computer science and information technology. Despite teaching computer fundamentals, many courses paradoxically make limited use of modern educational technologies. This contradiction not only represents a missed opportunity to enhance learning but also fails to model the effective use of technology that students should be developing.

The information age has brought forth new expectations and requirements for computer fundamentals education. Modern education must focus on developing students' ability to think algorithmically, decompose complex problems, and design systematic solutions. This goes beyond technical skills to encompass fundamental ways of thinking about problems and solutions. Students need opportunities to apply theoretical knowledge to real-world problems and develop innovative solutions. Recognizing the diversity of student backgrounds, learning preferences, and career goals, modern education must provide more personalized learning paths that accommodate individual needs while maintaining educational standards and objectives.

3. THEORETICAL FOUNDATIONS FOR TEACHING MODEL INNOVATION

Constructivist learning theory provides a fundamental framework for understanding how students actively build knowledge through interaction with their environment and experiences (Piaget, 1977; Vygotsky, 1978). This theory, pioneered by scholars such as Jean Piaget and Lev Vygotsky, emphasizes that learning is an active process where learners construct new understanding based on their prior knowledge and experiences. In the context of computer fundamentals education, constructivism suggests that students learn most effectively when they actively engage with programming concepts, problem-solving scenarios, and real-world applications rather than passively receiving information[13].

This approach encourages students to experiment with code, test hypotheses, and learn from both successes and failures, leading to deeper understanding and better retention of computational concepts. The social aspect of constructivism, particularly Vygotsky's concept of the Zone of Proximal Development, highlights the importance of collaborative learning and peer interaction in the educational process (Vygotsky, 1978). This principle supports the implementation of group projects, peer programming, and collaborative problem-solving activities in computer education.

Blended learning theory combines the benefits of traditional face-to-face instruction with online learning components to create more effective and flexible educational experiences (Graham, 2006; Garrison & Vaughan, 2008). This approach recognizes that different learning objectives may be best achieved through different delivery methods and that students have varying preferences for how they engage with educational content. The theoretical foundation of blended learning rests on the principle of using each delivery method for its strengths. Online components can provide flexibility, accessibility, and opportunities for self-paced learning, while face-to-face interactions can facilitate immediate feedback, collaborative activities, and hands-on practice.

Personalized learning theory emphasizes the adaptation of educational experiences to meet individual student needs, preferences, and learning goals (Pane et al., 2017; Xie et al., 2019). This approach recognizes that students have different backgrounds, learning styles, paces, and interests, and that effective education should accommodate these differences. Modern information technology enables the implementation of personalized learning through adaptive learning systems, intelligent tutoring systems, and data-driven insights into student progress and challenges (Walkington & Bernacki, 2020; Chen et al., 2020). In computer education, personalized learning can manifest through adaptive programming exercises, customized project assignments, and individualized learning paths that allow students to focus on areas where they need additional support or challenge.

4. INNOVATIVE TEACHING MODEL DESIGN

The blended learning model represents a strategic combination of online and offline educational components designed to maximize learning effectiveness while providing flexibility and personalization. This approach integrates various online components including short, focused video

lectures covering specific programming concepts, allowing students to learn at their own pace and review materials as needed. Interactive online assessments provide automated quizzes and coding challenges that offer immediate feedback and help students identify areas for improvement. Virtual spaces where students can ask questions, share solutions, and engage in peer learning through discussion forums and collaborative platforms enhance the social aspect of learning. Cloud-based development platforms allow students to practice coding without installation barriers.

The offline components of this model focus on intensive problem-solving sessions during face-to-face meetings that tackle complex programming challenges and debugging difficult code. Practical sessions where students work on real hardware and software configurations provide hands-on laboratory experience. Team-based work on substantial programming projects that require coordination and communication develops collaborative skills. Personalized guidance sessions between instructors and students offer individualized support and mentoring.

This model offers temporal and spatial flexibility while maintaining the benefits of direct interaction. Students can access learning materials anytime, anywhere, while still receiving personalized support and engaging in collaborative activities that enhance their learning experience.

The flipped classroom model fundamentally restructures the traditional learning process by moving content delivery online and using class time for active learning and application (Bergmann & Sams, 2012; Bishop & Verleger, 2013). In the pre-class phase, students engage with instructional content independently through recorded lectures, reading assignments, and preliminary coding exercises. This self-directed learning allows students to absorb basic concepts at their own pace and come to class prepared for deeper engagement.

During the in-class phase, time is dedicated to higher-order learning activities such as problem-solving workshops, code reviews, debugging sessions, and collaborative projects. Instructors act as facilitators and mentors, providing targeted support where students need it most. The post-class phase involves students consolidating their learning through reflection exercises, advanced programming assignments, and peer collaboration on extended projects.

This model shifts the focus from passive information reception to active knowledge application, promotes student autonomy and responsibility, and enables more efficient use of valuable face-to-face time with instructors.

Project-based learning organizes education around substantial, real-world projects that integrate multiple learning objectives and provide authentic contexts for skill development (Thomas, 2000; Blumenfeld et al., 1991). The implementation involves choosing projects that reflect real industry needs and challenges, such as developing web applications, creating data analysis tools, or building mobile apps. Projects are designed to require students to combine technical programming skills with problem-solving, project management, and communication abilities.

The approach uses agile development methodologies that allow for continuous feedback, revision, and improvement through iterative development cycles. Students are evaluated based on their ability to deliver functional solutions rather than their performance on isolated tests, providing authentic assessment that mirrors professional expectations.

This approach enhances student motivation by connecting learning to real-world applications, develops comprehensive professional skills beyond technical competencies, and provides portfolio-worthy experiences that students can showcase to potential employers.

The personalized learning model uses technology and data analytics to customize educational experiences based on individual student characteristics and progress. This includes AI-powered systems that suggest learning materials, exercises, and projects based on student performance and learning patterns. Dynamic curriculum sequences adjust based on student mastery and learning preferences, allowing students to advance based on demonstrated skills rather than time spent in courses.

The model employs various assessment methods to accommodate different learning styles and provide comprehensive evaluation of student capabilities. Modern learning management systems, AI tutoring systems, and educational data analytics tools enable the implementation of truly personalized learning experiences that were not feasible with traditional educational approaches.

5. IMPLEMENTATION STRATEGIES FOR INNOVATIVE TEACHING MODELS

The successful implementation of innovative teaching models requires comprehensive development of high-quality educational resources that support diverse learning approaches and technologies. Institutions must invest in creating multimedia educational content including interactive tutorials, video demonstrations, virtual laboratories, and simulation environments. These resources should be designed with accessibility principles in mind, ensuring that all students can benefit regardless of their technical setup or physical abilities.

Developing collaborative platforms where educators can share resources, best practices, and innovative teaching materials creates a community of practice that accelerates innovation adoption. These platforms should facilitate easy discovery, adaptation, and customization of resources to meet specific institutional needs. Incorporating real-world case studies, current industry projects, and professional

software tools into the curriculum ensures that students gain relevant, up-to-date experience that translates directly to workplace readiness.

The transition to innovative teaching models requires significant investment in faculty development to ensure educators have the skills and confidence needed to implement new approaches effectively. Professional development programs should focus on helping faculty become proficient with educational technologies, online platform management, and digital content creation tools. This includes training on learning management systems, video production, and interactive content development.

Beyond technical skills, faculty need support in understanding and implementing new pedagogical approaches such as flipped classroom techniques, project-based learning design, and personalized instruction strategies. Establishing mentoring programs, peer collaboration networks, and ongoing professional development opportunities ensures that faculty can continue to grow and adapt as technologies and methodologies evolve.

Robust technological infrastructure forms the foundation for successful implementation of innovative teaching models. Implementing comprehensive platforms that support multimedia content delivery, interactive assessments, collaboration tools, and analytics capabilities is essential for modern computer education. Providing students with access to cloud-based programming environments eliminates technical barriers and ensures consistent access to necessary software and development tools. Ensuring reliable, high-speed internet access and appropriate hardware in classrooms and laboratories supports seamless integration of technology into the learning experience. Sustainable innovation requires institutional commitment and policy support that encourages and rewards educational excellence. Developing comprehensive evaluation frameworks that assess both traditional learning outcomes and new competencies such as collaborative skills, creative problem-solving, and technological fluency provides quality assurance. Creating recognition and reward systems that encourage faculty to experiment with new teaching methods and acknowledge successful innovations in education supports continued improvement. Implementing support systems that help students adapt to new learning models, including technical support, academic coaching, and peer tutoring programs, ensures student success in the transition to innovative approaches.

6. TEACHING EFFECTIVENESS EVALUATION AND REFLECTION

A comprehensive evaluation framework must assess multiple dimensions of educational effectiveness to provide meaningful insights into the success of innovative teaching models. Learning outcome assessment involves measuring students' understanding of fundamental computer science concepts through both traditional and practical assessments. Evaluating practical programming abilities, problem-solving skills, and technical competencies through project portfolios and practical examinations provides insight into skill development. Assessing the development of information literacy, computational thinking, and professional skills necessary for success in technology careers demonstrates competency growth.

Process evaluation metrics include monitoring student participation in online discussions, completion rates for optional activities, and voluntary engagement with additional resources to gauge engagement levels. Analyzing the depth and quality of student-instructor and peer-to-peer interactions in both online and offline environments provides insight into interaction quality. Collecting feedback from students and faculty about their experiences with innovative teaching approaches through satisfaction surveys offers valuable perspectives on the effectiveness of implemented changes.

Preliminary implementation of these innovative teaching models has shown promising results across multiple institutions and contexts. Students demonstrate significantly higher levels of active participation in courses that employ blended learning and project-based approaches. Attendance rates, assignment completion rates, and voluntary participation in supplementary activities all show marked improvements compared to traditional teaching methods.

Assessment results indicate that students in innovative programs develop stronger practical programming skills and demonstrate better ability to apply theoretical knowledge to real-world problems. Portfolio assessments reveal more sophisticated and creative project work. Faculty report that innovative teaching models, while requiring initial investment in preparation and training, ultimately lead to more efficient use of classroom time and more meaningful interactions with students. The ability to address individual student needs while maintaining classroom cohesion represents a significant improvement over traditional approaches.

7. CONCLUSION

This research demonstrates that innovative teaching models can significantly enhance the effectiveness of computer fundamentals education in higher education institutions. The integration of information technology into educational practice, when supported by sound pedagogical theory and comprehensive implementation strategies, creates learning environments that better serve both students and educators.

The blended learning, flipped classroom, project-based learning, and personalized learning models each offer unique advantages that address specific challenges in traditional computer education. Their

successful implementation requires coordinated efforts in resource development, faculty training, technology infrastructure, and institutional policy support.

Future research should focus on long-term longitudinal studies to assess the sustained impact of these innovations on student career outcomes, continued refinement of personalized learning algorithms and systems, and exploration of emerging technologies such as virtual reality and artificial intelligence in educational contexts. The transformation of computer fundamentals education represents not just an opportunity to improve individual courses, but a chance to model the innovative, technology-enhanced approaches that students will need to succeed in their future careers and contribute to the continued advancement of the field.

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Research on the Dual-Attribute Integration Reform of "Academic and Vocational" Nature of the "Electrical Control and PLC" Course in Higher Vocational Undergraduate Colleges

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Abstract: Against the background of the transformation of higher vocational colleges to undergraduate-level institutions, the course Electrical Control and PLC, a core course for technical majors such as Electrical Automation and Intelligent Manufacturing, must align with the training goal of "undergraduate-level technical and skilled talents". It needs to simultaneously undertake the dual educational missions of "academic nature" (cultivating engineering thinking, systematic analysis, and theoretical application capabilities) and "vocational nature" (polishing on-the-job operation, technology implementation, and problem-solving abilities). Aiming at the common problems in current teaching—insufficient academic depth, disconnected vocational scenarios, and fragmented integration of dual attributes—this paper constructs a reform framework from four dimensions: reconstructing curriculum objectives, innovating content systems, optimizing teaching modes, and improving evaluation mechanisms. By clarifying the core logic of integrating "academic + vocational" attributes, the course forms a new model featuring "academic deepening of theoretical modules, vocational implementation of practical modules, and dual-attribute penetration of project modules". This reform provides a practical solution for balancing "academic nature" and "vocational nature" in technical courses of undergraduate-level vocational education and cultivating compound talents meeting industrial demands.

Keywords: Electrical Control and PLC; Undergraduate-level vocational education; Academic nature; Vocational nature; Curriculum reform.

1. NECESSITY OF INTEGRATING "ACADEMIC + VOCATIONAL" DUAL ATTRIBUTES IN ELECTRICAL CONTROL AND PLC

1.1 Aligning with the Core Orientation of Undergraduate-Level Vocational Education

Undergraduate-level vocational education focuses on cultivating "undergraduate-level technical and skilled talents", distinguishing itself from the "academic-oriented" training of general undergraduate education (which emphasizes theoretical research) and the "vocational-oriented" training of higher vocational education (which emphasizes operational skills). This positioning requires courses to balance "academic depth" and "vocational relevance". If Electrical Control and PLC retains the traditional vocational teaching model of "valuing operation over principles", it will fail to meet the undergraduate-level academic requirements for "engineering thinking and system design". Conversely, copying the general undergraduate teaching logic of "valuing deduction over application" will deviate from the vocational orientation of "serving industrial needs" of undergraduate-level vocational education. Thus, integrating "academic + vocational" dual attributes is an inevitable choice for the course to match the orientation of undergraduate-level vocational education .[1]

1.2 Addressing the Practical Pain Points of Imbalanced Dual Attributes

Surveys on the course in multiple upgraded institutions reveal three major imbalances. First, insufficient academic nature: The theoretical module remains at the level of "PLC instruction explanation and simple logic derivation", with limited coverage of in-depth academic content such as "PLC control algorithm optimization" and "industrial bus communication protocol principles". This leaves students unable to understand the design logic of complex control systems—for example, when learning "PLC sequential control", most courses only demonstrate basic programming for "single-cylinder reciprocating motion" but rarely

introduce "finite state machine theory" to help students model multi-station collaborative control. Second, disconnected vocational nature: Practical projects are mostly "verification experiments" (e.g., single motor start-stop control), lacking real on-the-job tasks like "automated production line collaborative debugging". A survey of 50 local automation enterprises shows 78% of employers believe graduates can only complete simple PLC programming but cannot handle tasks such as "PROFINET protocol configuration for PLC and industrial robots". Third, lack of integration: Academic theory and vocational practice are separated. When explaining "PLC communication principles", for instance, only protocol frame structure derivation is taught without linking it to "PROFINET protocol application in intelligent sorting lines", leading to students being "able to understand theory but not apply it, or able to operate but not understand the principles".

1.3 Responding To Industrial Demand for Compound Technical Talents

With the advancement of intelligent manufacturing and Industry 4.0, enterprises' demand for electrical automation talents has shifted from "single operation-oriented" to "compound innovation-oriented". Employees are required to master not only vocational skills like PLC programming and equipment debugging but also academic abilities such as "control system optimization design" and "complex fault root cause analysis". For example, when recruiting "PLC application engineers", enterprises require not only independent completion of production line PLC programming but also optimization of program efficiency based on control theory (e.g., reducing scan cycle time by optimizing logic structure) and design of fault redundancy schemes based on reliability engineering (e.g., dual-PLC backup for key control links). This demand change compels the course to break the barrier between "academic" and "vocational" and build an integrated teaching system .[2]

2. REFORM FRAMEWORK FOR INTEGRATING "ACADEMIC + VOCATIONAL" DUAL ATTRIBUTES

2.1 Reconstructing "Dual-Dimension, Four-Level" Curriculum Objectives

Centering on "academic" and "vocational" cores, the curriculum objectives are divided into four progressive levels:

Basic Theory Level: Academically, students master the core logical system of PLC working principles and industrial communication protocols (e.g., understanding the correlation between PLC scan cycle and control accuracy); vocationally, they convert theory into abilities like PLC hardware selection (e.g., choosing modules based on electromagnetic compatibility theory) and I/O address allocation.

Engineering Thinking Level: Academically, students use systematic analysis methods (e.g., finite state machine theory) to solve complex problems; vocationally, they develop PLC control system design schemes based on on-the-job tasks (e.g., optimizing production line action sequences to avoid equipment conflicts).

On-the-Job Skill Level: Academically, students understand the theoretical basis of operational skills (e.g., logic error detection principles in PLC debugging); vocationally, they master core skills like PLC programming (LD/STL/SCL languages), HMI development, and fault diagnosis, meeting enterprise operational standards.

Innovation Application Level: Academically, students improve control schemes via control theory (e.g., optimizing conveyor speed regulation with PID algorithms); vocationally, they design innovative projects using new technologies like digital twins (e.g., developing a PLC-virtual simulation remote debugging system).

2.2 Innovating the "Three-Module, Dual-Integration" Content System

Breaking the traditional "theory + practice" linear structure, a three-module system is built for two-way penetration of academic theory and vocational practice:

Basic Theory Module (Academic-oriented, Vocational-assisted): On the basis of retaining "PLC instruction system" and "electrical control circuits", in-depth academic content is added. When teaching "sequential control", finite state machine theory is introduced to express control logic with mathematical models; when explaining "industrial communication protocols", PROFINET/MODBUS principles are analyzed from the OSI seven-layer model. Each theoretical point is matched with vocational cases—for example, using "auto parts production line PLC program optimization" to explain how scan cycle affects control accuracy.

On-the-Job Practice Module (Vocational-oriented, Academic-assisted): Focusing on typical tasks of "automated equipment commissioning engineers" and "production line operation and maintenance engineers", practical content includes basic skill training (e.g., PLC hardware configuration, with students explaining wiring safety standards), comprehensive training (e.g., intelligent sorting line control, with students submitting "control scheme analysis reports"), and fault diagnosis training (using fault tree analysis to avoid blind trial and error).

Comprehensive Project Module (Dual-attribute integration): Taking complex industrial projects

(e.g., automated production line control, intelligent warehouse PLC linkage) as carriers, students complete academic tasks (e.g., control system modeling, reliability evaluation) and vocational tasks (e.g., PLC wiring, HMI development). They finally output "project design reports (academic analysis)" and "on-the-job operation manuals (skill specifications)", forming a "academic research → vocational practice" closed loop.[3]

2.3 Optimizing The "Dual-Teacher Collaboration + Virtual-Physical Integration" Teaching Mode

Dual-Teacher Team: Academic tutors (university teachers with engineering backgrounds) teach theories (e.g., PLC control algorithms), while enterprise tutors (senior engineers from Siemens/Mitsubishi) guide vocational practice (e.g., on-site PLC debugging). When teaching "PLC-industrial robot collaborative control", academic tutors explain theoretical models, and enterprise tutors demonstrate automobile welding line linkage, helping students grasp both logic and operation.

Virtual-Physical Platform: The virtual platform (e.g., TIA Portal simulation) is used for academic verification (testing algorithm optimization schemes), and the physical platform (e.g., Siemens S7-1200 training equipment) for vocational implementation (debugging verified programs on real devices), complementing scenarios and reducing equipment loss.

2.4 Improving The "Dual-Attribute, Diversified" Evaluation Mechanism

A 100-point system covering "academic + vocational" abilities is established:

Academic Ability (40%): Includes theoretical assessment (e.g., "designing PLC redundancy schemes with theoretical basis") and academic reports (analyzing project algorithm optimization).

Vocational Ability (45%): Includes skill operation (assessing programming proficiency, fault diagnosis efficiency) and project results (evaluating scheme feasibility, document standardization), with enterprise tutors participating in scoring.

Integration Ability (15%): Assesses theory-practice combination (e.g., explaining practical problem roots) via classroom questions and project defenses.

3. KEY CHALLENGES AND SOLUTIONS IN REFORM IMPLEMENTATION

3.1 Insufficient "Dual-Qualified" Teachers

Most teachers have solid theoretical foundations but lack industrial experience—some can explain "PLC communication principles" but cannot guide PROFINET configuration. Solution: Establish a "teacher-industry exchange" mechanism: arrange 1-2 months of enterprise practice for full-time teachers yearly, and hire part-time enterprise engineers as long-term tutors.

3.2 High Platform Construction Cost

Virtual simulation software (e.g., TIA Portal) and physical equipment (e.g., Siemens S7-1500) require high investment. Solution: Adopt "school-enterprise co-construction": enterprises provide equipment/technical support, and schools provide venues/talent training, establishing joint laboratories to reduce financial pressure and align with industrial technology.

4. EXPECTED REFORM EFFECTS

The reform is expected to achieve three outcomes: First, students' "dual abilities" will improve—1+X certificate pass rates may rise by 30%, and post-adaptation periods shorten from 3-6 months to 1-2 months. Second, course dual-attribute integration will optimize, with over 80% of students using theory to guide practice. Third, the reform provides a promotable model for courses like Industrial Robot Technology, driving overall curriculum reform.

5. CONCLUSION

The integration of "academic + vocational" dual attributes in the Electrical Control and PLC course is far from a simple superposition of theoretical knowledge and operational skills; it represents a deep "resonance" between academic logic and vocational logic. In this integration, academic theory serves as the "methodological support" for vocational practice—enabling students to not only "know how to operate" but also "understand why to operate that way"—while vocational practice acts as the "verification and transformation carrier" for academic theory, turning abstract principles into tangible problem-solving tools. As intelligent manufacturing continues to evolve, with emerging technologies like digital twins, industrial Internet, and artificial intelligence increasingly integrating into industrial control systems, the course must maintain dynamic adaptability: it should regularly update "academic knowledge points" (such as adding content on AI-driven PLC control algorithm optimization) and "vocational task points" (such as incorporating virtual commissioning of intelligent production lines), ensuring that the curriculum remains aligned with industrial development trends. Meanwhile, strengthening the construction of "dual-qualified" teachers is equally critical—only by equipping teachers with both solid academic literacy and rich industrial experience can they effectively guide students in bridging the gap between classroom learning and on-site practice. Ultimately, this reform aims to continuously promote the course towards "in-depth integration, dynamic

adaptation, and quality improvement", providing stronger curriculum support for undergraduate-level vocational education to cultivate "undergraduate-level technical and skilled talents who possess both theoretical depth and practical ability, and can quickly adapt to the needs of the new industrial era".

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Research on Professional Development of English Teachers in Vocational Colleges Under the “Internet plus” Model

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Abstract: With the development of the times and advanced technology, Internet technology has been applied unprecedentedly, and a variety of Internet platforms have emerged endlessly. Among them, here is the combination of professional development of vocational English teachers and "Internet plus". It is necessary and meaningful for us to explore multiple paths for the self-development of vocational English teachers relying on the Internet.

Keywords: Internet; Vocational English Teachers; Professional Development

1. CURRENT RESEARCH STATUS AT HOME AND ABROAD

The most important advantage of the "Internet plus" era is the application of multimedia teaching, which displays teaching contents in digital forms. In many cases, the current English teaching in higher vocational colleges still adopts the traditional teaching form, that is, teachers give priority to teaching, but it is difficult to meet the professional development needs of teachers. It is of great significance to explore effective ways to promote the professional development of teachers by connecting the advantages of English teaching in higher vocational colleges in the "Internet plus" era, so as to improve the current level of higher vocational education, and cultivate high-quality talents who can adapt to the current innovation and entrepreneurship background.

Compared with Western countries, research on English education in China, especially on teacher development, started relatively late. Therefore, we urgently need English teachers to improve their abilities through external conditions. We can see that the smooth implementation of vocational English teaching requires hardware facilities and the interaction between software and courses. However, it is of great significance to improve the professional ability of English teachers in higher vocational colleges if we want to combine Internet application technology with English teaching in higher vocational colleges organically and efficiently.

2. THE PROBLEMS IN THE CURRENT PROFESSIONAL DEVELOPMENT PROCESS OF VOCATIONAL ENGLISH TEACHERS

The professional development of vocational English teachers not only refers to the improvement of their professional abilities, but also to their own development and changes, which is the development of self-awareness and the realization of self-worth.

2.1 Problems Related To the Teachers

At present, the quality of vocational English teachers is not high, and there are few personnel with senior professional titles. English teachers generally receive pure language education and lack professional knowledge. While imparting knowledge, students may not be able to find a point of relevance to their major, which can easily lead to resistance. The teaching task of teachers is also heavy, requiring them to explain a lot of knowledge to students in limited time, lacking time to research teaching methods, understand students, let alone improve teaching quality and innovate teaching forms.

2.2 Problems Related To the School

Vocational colleges generally develop annual teaching plans based on the goal of cultivating applied talents. On the one hand, it is necessary to ensure the total number of teaching hours, and on the other hand, attention should be paid to the development of professional courses. Therefore, English courses are gradually being marginalized. However, English courses involve a large number of students, and the school cannot achieve unified coordination. English teachers are not valued and have lost some enthusiasm. This leads to some teachers only being satisfied with completing current teaching tasks, lacking innovation, let alone scientific research. So the dilemma faced by vocational English teachers is closely related to the inadequate management system of the school.

2.3 Problems Related to Others

The professional development of vocational English teachers is insufficient[1] and is also influenced by external factors such as family and society. As for it, it has not received enough attention from both families and society. Parents' expectations for their children's English education mainly focus on test ability, especially passing the English proficiency test, which is seen as a stepping stone to find a job. Therefore, teachers place more emphasis on imparting knowledge during the teaching process rather than combining it with other professional knowledge to arouse students' interest in learning.

3. RESEARCH PATHS OF PROFESSIONAL DEVELOPMENT OF ENGLISH TEACHERS IN VOCATIONAL COLLEGES BASED ON THEIR OWN RESOURCES UNDER THE “THE INTERNET PLUS” MODEL

The development of teachers themselves requires mutual cooperation between individual teachers and their surrounding environment. Its development also has long-term and practical characteristics. In this process, vocational English teachers need to adopt an open, cooperative, and win-win attitude, constantly learning and reflecting,and strive for more rights and development space for oneself.

3.1 Expand One’S Own Knowledge Field, Form A Self-Awareness of Constantly Improving Professional Development, and Strenthen The Construction Of A “Dual Teacher” Teaching Team

In the development process of human history, we can find that regardless of the society or type of education, the participation of teachers is the key to success. The participation of teachers plays a decisive role. Therefore, in the current context of vocational education reform, the development situation of vocational English teachers is no longer sufficient, and it is necessary to actively change the situation, especially to improve their professional quality and enhance their teaching ability[2].

We are now living in a highly information-based era, accompanied by the popularization and application of multimedia terminal devices such as computers and mobile phones. As teachers, especially English teachers, we should pay attention to integrating learning and use our leisure time for targeted learning. Not only should one focus on acquiring English knowledge related to their profession, but they should also utilize the supplementary role of non classroom teaching places to increase their learning and accumulation efforts. And teachers should combine in class and out of class activities to increase one's interdisciplinary background knowledge, promote the continuous growth and realization of self-worth of vocational English teachers, and quickly transform into "dual teacher" English teachers. Among them, English teachers should always be aware of which abilities are more emphasized in English by employers. Actively participate in various industry qualification exams to improve one's professional and cognitive abilities.

3.2 Create a Good Environment

As we are in the era of "Internet plus"[3], schools, as managers, organizers, advocates and evaluators, should promote the sharing and utilization of resources. Colleges should provide support for English teachers in terms of institutional mechanisms, time, material conditions, and other aspects. Especially to improve the evaluation mechanism and attach importance to the combination of teacher work and professional knowledge. Actively create a more open platform for vocational English teachers to learn and share. By providing a harmonious and friendly working environment for English teachers, we aim to offer them a higher and broader platform for their professional development. English teachers can leverage the advantages of the platform, efficiently utilize favorable educational information, improve their professional abilities, establish mechanisms in schools, enhance awareness, increase training, and conduct scientific research and development. We should encourage English teachers to intern in the industry and understand the demand for vocational college students in society and pay attention to selecting teachers to study abroad or introducing foreign part-time teachers, and establish a team of English teachers with high professional level and strong work ability.

3.3 Use The Means of “Internet Plus” To Establish The Awareness of Lifelong Learning And Enhance Their Own Development Momentum

As a vocational English teacher, we should strive to break through the constraints and limitations brought by traditional concepts. To position oneself reasonably and constantly innovate, we should actively use the modern information technology brought by "Internet plus", keep learning and contributing to higher vocational education.

4. CONCLUSION

In summary, the current research on the professional development of vocational English teachers not only involves the continuous learning and accumulation of professional knowledge, but also contains the combination of the contents of the courses taught by teachers, teaching psychology, and other knowledge. Based on the issues mentioned in the article regarding teachers, schools, and other aspects, we know that English teachers currently lack learning time, face excessive pressure, and do not know how to improve their professional abilities. In order to realize the professional development of English teachers in vocational colleges, we should explore from the teachers themselves, use the "Internet plus" model, provide more opportunities for further study, adopt more policies to encourage teachers, and let English teachers create more value in the process of real self-awareness. By combining one's own subjective initiative, we should cultivate the outstanding talents needed by society. General Secretary Xi Jinping once proposed that education is the foundation of a century long plan. Teachers are the foundation of an education plan. The self-development of teachers is a key point for the success of school development and national education reform. We must constantly strive for this and strive to cultivate more outstanding vocational talents for the country.

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Exploration of the Optimization Path for Cultivating Low-Carbon Awareness among College Students in the New Era

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Abstract:Under the guidance of the concept of ecological civilization in the new era, enhancing the ecological literacy of young people has become an important issue for national development. As the backbone of the future society, the cultivation of low-carbon concepts and environmental behaviors among college students is directly related to the implementation of green development strategies and the achievement of sustainable development goals. Based on the characteristics of contemporary youth education, this article explores the constituent elements of low-carbon awareness among college students from four levels: values, responsibility cognition, consumption behavior, and practical ability. It proposes to construct a comprehensive and immersive low-carbon education mechanism through multiple channels such as curriculum integration, cultural influence, practical guidance, and independent participation, effectively improving the cultivation effect of low-carbon literacy among college students.

Keywords: Low-carbon concept; College student; Ecological education; Dual carbon targets; Cultivation Path

1. THE CORE DIMENSION OF CULTIVATING LOW-CARBON AWARENESS

The "dual carbon" target not only demonstrates China's great power responsibility in participating in global environmental governance, but also is a key measure in the process of ecological civilization construction. This transformation covers multiple aspects of economy, society, and culture, with long-term and systematic characteristics, and requires the coordinated promotion of the whole society. As the core force of modernization construction, college students' low-carbon cognition and behavioral choices directly affect the implementation effectiveness of the "dual carbon" strategy. Therefore, cultivating low-carbon concepts among college students and promoting their transformation into conscious actions has become an urgent need to achieve national green development[1].

(1)Establishing the concept of a community of shared life between humans and nature

General Secretary Xi Jinping emphasized that the international community should work together to build a community of shared life between humans and nature. This concept suggests that humans and nature should establish a balanced and symbiotic relationship, and while utilizing nature, humans must also bear the responsibility of protection. The education of a community of shared life aims to guide students to abandon anthropocentrism, recognize that the destruction of nature will ultimately backfire, and establish an ecological civilization concept that respects, conforms to, and protects nature, placing ecological integrity at the forefront of behavioral choices[2].

(2)Strengthening the Ethics of Ecological Civilization Responsibility

The sense of responsibility for ecological civilization originates from human moral consciousness and behavioral constraints towards nature, and continues to mature with the deepening of self-awareness, promoting the harmonious coexistence between humans and nature. It not only requires recognition of human moral obligations towards ecology, but also emphasizes a value position centered on the ecological whole, surpassing the limitations of traditional anthropocentrism. The responsibility of ecological civilization is an important component of contemporary civic literacy and also an essential part of the comprehensive development of college students. This awareness needs to be gradually constructed through educational guidance, so that college students can internalize responsibility into moral principles, and manifest it as compliant behavior and conscious participation.

(3)Advocate the concept of green consumption

Green consumption reflects the dual pursuit of a better life and ecological environment in society. Low carbon, environmentally friendly, and circular consumption patterns are increasingly becoming a new trend in society. The awareness of green consumption economy aims to guide college students to abandon extravagance and waste, and shift towards rational, moderate, and responsible consumption behavior. It includes two levels: one is the material level, prioritizing the selection of environmentally friendly and pollution-free products; The second aspect is the spiritual level, emphasizing the quality and sustainability of spiritual consumption, and resisting the erosion of consumerism. The cultivation

of this awareness focuses on promoting the combination of conceptual transformation and practice[3].

(4)Promoting low-carbon practices that integrate knowledge and action

Low carbon awareness not only requires proper cognition, but also emphasizes action transformation. College students should actively practice energy conservation and emission reduction in their daily lives, participate in environmental protection activities, and achieve a leap from awareness to action. Practical awareness can be divided into two categories: one is shallow practice based on policy compliance or external requirements, which has a certain degree of passivity; The other type is deep practice that stems from inner identification, with initiative and sustainability. Education should promote students to gradually deepen their understanding of low-carbon concepts and transform them into sustainable behavioral habits and core competencies. Through personal participation and practical experience, college students can deepen their recognition of low-carbon values and achieve the unity of thought and action[4].

2. THE EPOCHAL VALUE OF CULTIVATING LOW-CARBON AWARENESS AMONG COLLEGE STUDENTS

Low carbon awareness is a moral guidance and behavioral standard condensed by human interaction with nature over a long period of time. It represents a cutting-edge ideological concept that constantly elevates with the progress of human society, aiming to promote a beautiful vision of harmonious coexistence between humans and nature. At present, cultivating low-carbon awareness among college students is of immeasurable significance, whether from the macro perspective of national strategy, the construction of ecological civilization education system in universities, or the shaping of personal growth and lifestyle of college students.

(1)Cultivating low-carbon awareness among college students helps achieve carbon peak and carbon neutrality goals

Ideas and concepts are the compass of behavior. As the future pillars of the socialist cause, college students' low-carbon awareness will directly affect their actions in socialist modernization construction. In the journey towards carbon peak and carbon neutrality, it has become an urgent need to cultivate low-carbon awareness among college students and guide them to engage in low-carbon practices.

When college students establish a low-carbon awareness, they will actively enhance their scientific research and innovation capabilities, focus on key core technologies such as zero carbon and negative carbon, and create a large number of innovative achievements in the field of green and low-carbon, laying a solid talent foundation for achieving carbon peak and carbon neutrality. At the same time, cultivating low-carbon awareness can comprehensively enhance the ecological civilization literacy of college students and strengthen China's soft power in the field of ecology. This will help transform the grand vision of carbon peak and carbon neutrality into conscious actions of all college students, creating a strong cultural atmosphere of green and low-carbon living on campus, and thus building a solid cultural support for achieving carbon peak and carbon neutrality.

(2)Cultivating low-carbon awareness among college students is an inevitable step in the construction of the ecological civilization education system in universities

The ecological civilization education system aims to promote harmonious coexistence, virtuous cycle, comprehensive development, and sustained prosperity among people, people and nature, and people and society. In this system, low-carbon awareness occupies an extremely important position and is a cutting-edge manifestation of the close integration of ecological civilization education system with the times.

Cultivating low-carbon awareness among college students can guide them to establish a sense of community of life between humans and nature, strengthen their awareness of ecological civilization responsibility, establish a green consumption economy awareness, and transform these awareness into practical actions. By actively participating in the construction of ecological civilization, college students continuously develop and improve the connotation of ecological civilization education in practice. Cultivating students' low-carbon awareness can help them internalize and externalize the concept of "harmonious coexistence between humans and nature" in their hearts and actions, independently practice green low-carbon living, achieve the unity of cognition, emotion, will, and action, and comprehensively enhance their ecological civilization literacy.

(3)Cultivating low-carbon awareness among college students is a key path to shaping their green lifestyle

Low carbon awareness represents a new concept of green, environmentally friendly, and sustainable living.A green lifestyle is of great benefit to the physical and mental health of college students, and can also avoid the burden on families and society caused by blind comparison. An environmentally friendly lifestyle can regulate the daily behavior of college students, motivate them to actively participate in environmental protection practices, and contribute to the construction of national ecological civilization. A sustainable lifestyle can help college students develop simple and moderate living habits, and uphold the principles of green and moderation in future consumption. Through the cultivation of low-carbon awareness, college students can deeply understand the correctness and value of a "simple,

moderate, green and environmentally friendly" lifestyle, and consciously practice it; At the same time, we firmly resist the erroneous behavior of "luxury, waste, and unreasonable consumption".

3. THE REALISTIC PATH FOR CULTIVATING LOW-CARBON AWARENESS AMONG COLLEGE STUDENTS IN THE NEW ERA

Faced with the heavy responsibility of the "dual carbon strategy", cultivating low-carbon awareness among college students with high standards is an important part of ideological and political education in universities and a necessary measure to cultivate talents for building a socialist modernized country.

(1)The key to integrating low-carbon education into ideological and political courses in universities is to deeply integrate the teaching content of both. Promote the integration of low-carbon education content into the textbook system and teaching system: Textbooks are the key carrier for integrating low-carbon education into ideological and political courses. We should optimize the teaching content reasonably based on the curriculum objectives of each ideological and political course, integrate low-carbon education content into the textbook, and make its essence run through it, forming a rigorous and perfect structural system. At the same time, low-carbon education content should be integrated into the teaching system, such as in the "Basic Principles of Marxism" course, combining the chapters of practice and understanding the laws of development, to cultivate students' practical awareness of the integration of knowledge and action。

In the course of "Ideology, Morality and Rule of Law", combined with the chapter on moral norms, cultivate students' awareness of green consumption. Enriching teaching methods and improving teaching effectiveness: Teaching methods are the bridge that transforms low-carbon education knowledge into students' cognition. We should actively innovate teaching methods to make low-carbon education accessible to our ears, minds, and hearts. On the one hand, building a low-carbon education network platform, utilizing modern means to showcase ideological and political course content, and improving teaching effectiveness. On the other hand, promoting the coordinated development of ideological and political courses, integrating low-carbon education into professional course teaching, such as guiding students to think about the relationship between professional knowledge and ecological protection when teaching forestry majors.

(2)Emphasizing the construction of low-carbon culture on campus and cultivating low-carbon awareness among college students cannot be separated from a good campus low-carbon culture, which plays a role in guiding values and regulating behavior. Effectively utilizing low-carbon education cultural elements in universities: Universities should create a good cultural atmosphere and enhance the status of low-carbon education. On the one hand, we should strengthen the construction of campus material culture, integrate low-carbon elements into campus landscapes, dormitories, canteens, and other constructions, and achieve the unity of aesthetic, practical, and educational functions. On the other hand, we will strengthen the construction of campus spiritual culture, invite experts to hold lectures, promote green and low-carbon lifestyles, integrate low-carbon elements into school history and motto, and provide in-depth explanations at freshman class meetings to cultivate students' emotional identification. Carry out themed education and create a low-carbon cultural atmosphere: Students participating in low-carbon education volunteer activities can deepen the concept of "green development". On the one hand, we will carry out themed education on "green, low-carbon, ecological and environmental protection" volunteer services, and use various methods to build a first-class volunteer service team. On the other hand, we will carry out low-carbon skills themed education, encourage professional talents to participate in low-carbon practices, establish a sound training system and talent cultivation mechanism, develop relevant apps or mini programs, and guide students to participate in low-carbon practices scientifically.

(3)Enriching social low-carbon practice models can help college students cultivate their character and enhance their sense of responsibility. Enriching social low-carbon practice models is an inevitable choice to enhance college students' low-carbon awareness. Integrating social resources and carrying out low-carbon practices: The key to effectively carrying out low-carbon education lies in integrating social resources. On the one hand, utilizing public facilities such as museums and science museums to carry out low-carbon practices and guide students to recognize the value of low-carbon education. On the other hand, exploring low-carbon practice models for innovation and entrepreneurship, combining innovation and entrepreneurship with low-carbon practices, encouraging students to use their professional knowledge to carry out practical activities, the government should increase incentive policies to mobilize students' enthusiasm. Promote school enterprise cooperation and cultivate low-carbon talents: Universities should actively cooperate with enterprises, such as high-tech enterprises, ecological farms, etc., to lead students to visit and learn, and jointly create a "green low-carbon talent" incubation base. At the same time, the government should establish a deep integration incentive mechanism for industry, education, and research, guide enterprises to develop low-carbon products, increase financial investment, and promote school enterprise cooperation.

(4)Enhancing students' self-education ability is an

important criterion for measuring the effectiveness of low-carbon education in universities. Universities should guide students to carry out self-education. Strengthening the learning of low-carbon concepts and internalizing low-carbon awareness into self-consciousness: The cultivation of students' self-education ability is influenced by both internal and external factors. To strengthen the learning of low-carbon concepts, on the one hand, traditional methods such as classroom education and reading relevant books should be used to enhance ecological civilization literacy; On the other hand, modern means such as online information platforms and VR technology are utilized to enrich learning content and deepen understanding of the importance of low-carbon education. Developing a green lifestyle and externalizing low-carbon awareness into initiative: Strengthening one's own low-carbon education ability requires putting low-carbon awareness into practice. College students should cultivate green behavior habits, such as refusing excessive packaging, reducing the use of disposable products, and choosing green modes of transportation. At the same time, cultivate green consumption patterns, abandon excessive consumption and comparison mentality, reflect on consumption habits, and practice green consumption.

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Research on the Development Status and Trends of Overvoltage Protection Technology

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Abstract: Overvoltage protection is a core technology for ensuring the safe and stable operation of power systems, electronic equipment, and buildings. Its development level is directly related to the safety of the national economy and people's lives and property. This paper systematically discusses the overall development context, current status, and future trends of overvoltage protection technology. The article first explains the generation mechanism and hazards of overvoltage, emphasizing the necessity of protection. Secondly, it details and compares the development status of overvoltage protection technology domestically and internationally, focusing on the principles, characteristics, and applications of traditional power system protection technologies represented by Metal Oxide Arresters (MOAs) and modern electronic equipment protection technologies represented by Transient Voltage Suppression (TVS) diodes and Thyristor Surge Suppressors (TSS). The paper points out that while China has achieved international leadership in high-end power protection fields like Ultra-High Voltage (UHV), gaps still exist compared to top global levels in basic materials, core components, and chip-level protection technologies. Finally, the paper looks ahead to future trends where overvoltage protection technology develops towards intelligence, integration, multi-level coordination, and environmental sustainability, emphasizing the critical role of intelligent monitoring, big data analytics, and new material applications in future technological competition.

Keywords: Overvoltage Protection, Metal Oxide Arrester (MOA), SPD (Surge Protective Device), Intelligence, Multi-level Coordination, Technological Development

1. INTRODUCTION

As the primary form of energy in modern society, the quality and security of electricity supply are paramount. During operation, power systems inevitably face overvoltage threats from external sources (e.g., lightning strikes) and internal sources (e.g., switching operations, faults). The magnitude of these overvoltages often far exceeds the withstand limit of equipment insulation, potentially causing equipment damage and system outages in minor cases, or triggering serious accidents like fires and explosions in severe cases, leading to significant economic losses and social impact. Statistics show that a considerable portion of power system failures are directly or indirectly caused by overvoltages. Therefore, overvoltage protection technology has always been a focus of research and application in fields such as electric power, electronics, telecommunications, and construction. Overvoltage protection technology aims to provide a low-impedance release path for overvoltage energy and clamp it to a safe range that protected equipment can withstand, thereby serving the dual purpose of "diverting current" and "limiting voltage." From the earliest horn gap arresters to modern metal oxide arresters, from simple fuses to sophisticated integrated protection modules, overvoltage protection technology has undergone rapid development over more than a century, achieving revolutionary improvements in protection performance, reliability, and applicability. This study aims to comprehensively review the architecture of overvoltage protection technology, conduct an in-depth analysis of its domestic and international development status, and, based on technological evolution patterns and emerging needs, provide a forward-looking prediction of its future development trends, hoping to offer valuable reference for technological innovation and industrial upgrading in related sectors[1].

2. OVERVIEW OF OVERVOLTAGE PROTECTION TECHNOLOGY

Overvoltages can be primarily categorized into two types based on their cause:

External Overvoltages (Lightning Overvoltages): Caused by thundercloud discharge, including direct lightning strikes and induced lightning strikes. Their characteristics include extremely high amplitude (up to millions of volts), steep wavefront (microsecond level), and enormous energy, making them highly destructive[2].

Internal Overvoltages (Switching Overvoltages, Temporary Overvoltages): Caused by internal operations within the power system (e.g., switching unloaded lines, capacitor banks) or faults (e.g., single-phase grounding). Their amplitude is usually lower than lightning overvoltages, but they occur more frequently, and their cumulative damage to equipment insulation cannot be ignored.

Correspondingly, overvoltage protection devices have formed two major technological systems:

Power System Overvoltage Protection Devices: Mainly used in power generation, transmission, substation, and distribution links, protecting large electrical equipment like transformers, circuit

breakers, and busbars. Their characteristics are high current-carrying capacity and high withstand voltage levels. Representative products include: Metal Oxide Arresters (MOA), protective gaps, expulsion-type arresters, etc.

Electronic Equipment Overvoltage Protection Devices: Mainly used at the front end of low-voltage electronic equipment in fields such as communications, transportation, industrial control, and smart homes, protecting sensitive integrated circuit chips. Their characteristics are fast response time (nanosecond level), precise clamping voltage, but relatively small current-carrying capacity. Representative products include: Transient Voltage Suppression (TVS) diodes, Thyristor Surge Suppressors (TSS), Metal Oxide Varistors (MOV), Gas Discharge Tubes (GDT), etc. These devices are often combined into Surge Protective Devices (SPDs) installed in distribution boxes or equipment ports[3].

A complete protection scheme is typically multi-level and coordinated. The first stage (coarse protection) uses devices with strong current-handling capabilities (e.g., MOA, GDT) to divert most of the energy. The second stage (fine protection) uses fast-responding, precise clamping devices (e.g., TVS, TSS) to further limit the residual voltage to a safe level.

3. CURRENT DEVELOPMENT STATUS OF OVERVOLTAGE PROTECTION TECHNOLOGY ABROAD

Developed countries in Europe, America, and Japan started early in the field of overvoltage protection technology. They possess solid fundamental theoretical research and have long guided the direction of technological development. Their characteristics are mainly reflected in the following aspects:

Advantages in Materials Science and Basic Components: International giants such as Siemens, ABB, Phoenix Contact, Bourns, and STMicroelectronics have deep expertise in the material research of key protective components. For instance, they continuously innovate in zinc oxide resistor disc formulations and sintering processes, consistently improving their non-linear characteristics, energy absorption density, and anti-aging performance. Regarding semiconductor protection devices, their TVS diodes maintain leadership in parameters like response time, junction capacitance, and power density, and they continually launch multi-functional, modular chips integrating ESD, EFT, and surge protection[4].

High Reliability and Product Series: Foreign companies place extreme importance on product reliability and long-term stability. Their products are designed with large margins and long life cycles, capable of meeting extremely harsh application environments (e.g., severe cold, extreme heat, high salt spray). They provide a full range of product lines covering all voltage levels from kilovolt-class UHV to volt-class chip voltages, and they dominate high-reliability application fields (e.g., aerospace, military, automotive electronics).

Intelligence and System Integration: Foreign countries have taken the lead in deeply integrating Internet of Things (IoT) technology into the overvoltage protection field. Their high-end MOA and SPD products commonly integrate intelligent monitoring modules that can collect data such as leakage current, operation count, temperature, and energy discharge value in real-time and upload it to cloud monitoring platforms via wired or wireless means. Combined with big data analysis, this enables accurate assessment of equipment health status, fault early warning, and predictive maintenance, significantly improving operational efficiency and management levels. For example, ABB's Ability™ platform and Siemens' SENTRON PAC series offer complete digital protection solutions.

Standard Setting and Technological Influence: Standards established by organizations like the International Electrotechnical Commission (IEC) and Underwriters Laboratories (UL) (e.g., IEC 61643, UL 1449) have become globally accepted technical specifications and certification basis. Leading foreign enterprises deeply participate in and dominate the setting of these standards, solidifying their technological advantages into industry barriers and continuously consolidating their market leadership position[5].

4. CURRENT DEVELOPMENT STATUS OF OVERVOLTAGE PROTECTION TECHNOLOGY IN CHINA

China's overvoltage protection technology has achieved a tremendous leap from "following," "running alongside," to "leading" in some areas, accompanying the rapid rise of the power industry and information technology sector. However, imbalances still exist within the overall industrial ecosystem.

Global Leadership in the UHV Field: Leveraging the world's largest and most complex UHV grid projects, China has achieved remarkable accomplishments in UHV AC/DC arrester technology. Enterprises represented by China XD Group, Pinggao Group, and XJ Group Corporation have successfully developed ±1100kV and 1000kV series MOAs with completely independent intellectual property rights. Their voltage level, current-carrying capacity, and energy withstand capability and other hard indicators have reached top international levels, strongly safeguarding national energy strategy security[6].

Advantage in Mid-to-Low End Market and Dependence on High-End Components: In the conventional power arrester and civilian SPD market, domestic products, leveraging cost advantages and localized service, already occupy the vast majority of the domestic market share and are exported in large quantities. However, there is still some degree of

reliance on imports for high-end chip-level protection devices (e.g., high-performance TVS, TSS), key materials (e.g., high-purity, high-consistency zinc oxide powder), and precision processes. Domestic manufacturers like Will Semiconductor, Holykee are actively catching up, but gaps remain compared to the top global level in high-reliability, automotive-grade product fields.

Accelerating Technological Innovation and Standardization: Universities, research institutions, and enterprises in China are continuously increasing R&D investment. A large number of innovative patents have emerged in areas such as multi-gap structures, hybrid protection technologies, and new arc-extinguishing materials. China is also actively participating in international standard setting and transforming valuable experience from UHV projects into national and industry standards, significantly enhancing its international influence[7].

Intelligent Transformation in Its Infancy: Domestic companies are actively positioning themselves in the intelligent overvoltage protection field, introducing various types of intelligent SPDs with communication functions and online monitoring systems. However, the overall situation is still in its early stages. Compared to the most advanced foreign solutions, there is room for improvement in sensor accuracy, data model algorithms, system integration, and long-term operational reliability.

5. FUTURE DEVELOPMENT TRENDS

In the future, overvoltage protection technology will no longer be satisfied with "passive diversion" but will develop towards deep integration characterized by "active perception, intelligent decision-making, and coordinated protection."

Deep Intelligence and Digitization: "Intelligent protectors" integrated with AI chips and edge computing capabilities will become standard. They will not only monitor their own status and grid parameters in real-time but also use algorithms to predict lightning risk, assess overvoltage probability, and adjust protection strategies in advance (e.g., dynamically changing protection levels). Cloud platforms, by aggregating data from the entire network, can achieve regional coordinated protection, precise fault location, and full-network reliability analysis, ultimately forming a digital twin protection system[8].

Multi-level Coordination and System-Level Integrated Protection: Future protection design will emphasize "holistic solutions" more. By organically combining MOAs, SPDs, filter circuits, shielding technology, etc., full-spectrum, integrated protection against complex overvoltages (e.g., lightning, switching surges, oscillatory waves, ESD) can be achieved. Protection modules will be more deeply integrated functionally with protected equipment (e.g., photovoltaic inverters, charging piles, 5G base stations), achieving better matching and space utilization.

Application of New Materials and Principles: Wide-bandgap semiconductor materials (e.g., Silicon Carbide - SiC, Gallium Nitride - GaN), due to their excellent high-temperature resistance, high withstand voltage, and high-frequency characteristics, are expected to give rise to a new generation of solid-state protection devices with ultra-fast response, ultra-low residual voltage, and ultra-high reliability. Research and development of new varistor materials and composite materials will also continuously push the performance limits of existing MOAs and MOVs.

Environmental Protection and Miniaturization: As environmental requirements become stricter, developing green protection products and production processes that are lead-free, cadmium-free, and SF6-free will become mandatory. Simultaneously, as electronic equipment becomes increasingly compact, protection devices will inevitably develop towards miniaturization, chipization, and integration[9].

Addressing Challenges of New Power Systems: New power systems dominated by new energy sources bring new overvoltage problems. Developing specialized overvoltage protection devices and technical specifications applicable to emerging scenarios such as new energy generation, energy storage systems, and DC distribution networks will be an important growth area and research focus in the future.

6. CONCLUSION

Overvoltage protection technology is an interdisciplinary, cross-field comprehensive technology. Its development level is an important reflection of a country's industrial strength and technological innovation capability. Reviewing its development history, the following conclusions can be drawn:

First, China's overvoltage protection technology has made significant progress, especially under the pulling force of national major project needs like UHV power protection, achieving technological breakthroughs and industrial rise. Some areas have reached world-leading levels, possessing strong international competitiveness.

Second, we must clearly recognize that gaps still exist compared to the top international level in basic materials, high-end chips, precision manufacturing and other foundational areas, as well as in the hardware and software technologies deeply integrated with digitization and intelligence. This requires continuous national-level guidance for basic research and corporate adherence to long-termism to overcome "bottleneck" problems.

Third, the high ground of future technological competition will be intelligence and system-level solutions. Overvoltage protection devices will evolve from independent units into intelligent nodes within smart grids and the IoT, possessing capabilities for

perception, decision-making, and execution. New materials, artificial intelligence, and big data will become the core engines driving the next technological revolution.

In summary, China's overvoltage protection technology faces both opportunities and challenges. Only by adhering to independent innovation and open cooperation, and strengthening basic research and engineering application, can we take the initiative in this technological transformation, providing a solid guarantee for building a safe, reliable, and intelligent energy internet and digital economy system.

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Research on the New Model of "Prevention Education Intervention Feedback" Four Step Whole Chain Safety Education in Colleges and Universities

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Abstract: The current security risks faced by college students are complex and diverse, covering campus life, network environment, social practice and other aspects. However, there are some pain points in the safety education of college students, such as the imperfect education system, the single education form, the weak teaching staff, and the weak safety awareness of students, which restrict the actual improvement of the education effect. Combined with the development of Internet technology, the author puts forward the targeted improvement direction and effective measures, that is, to build a new model of "prevention education intervention feedback" four step safety education in the whole chain.

Keywords: Internet, College students, Safety education.

1. CURRENT SECURITY RISKS FACED BY COLLEGE STUDENTS

At present, the security risks faced by college students are complex and diverse, covering campus life, network environment, social practice and other aspects[1]. The main risks can be classified into the following categories.

1.1 Fire Safety of Dormitory

electrical fire: fire caused by illegal use of high-power electrical appliances (such as electric cookers, hair dryers, electric irons), unauthorized connection of wires, overcharge of power bank, use of inferior electrical appliances, etc. In 2024, college dormitory fires accounted for 46.9% of the total, of which electrical fires accounted for 54.8%.

combustible accumulation: inflammables such as cartons and clothes are stacked in balconies and corridors, which increases the risk of fire spread.

unattended electrical appliances: such as electric blankets and mosquito repellent incense, which are not closed in time after use, and lead to spontaneous combustion due to long-time power on[2].

1.2 Network Security and Fraud

Telecom fraud: being cheated through part-time bill swiping, impersonating teachers/public security organs, Internet loans and other means. Such events occur frequently during the summer vacation.

For example, a recent case: freshmen were lured to Cambodia, and college entrance examination students lost contact due to the scam of "high paid work".

Personal information disclosure: identity information was defrauded due to login to phishing websites and listening to false recruitment.

online gambling and illegal fund-raising: some students participate in online gambling or fall into pyramid schemes.

1.3 Personal and Property Safety

Traffic accidents: illegal riding on campus, taking vehicles without operation qualification outside campus, driving motorcycles without license, etc.

Violence and theft: robbery, sexual assault, dormitory property theft and other security incidents occur on and around the campus.

Drowning and sports injury: safety accidents due to outdoor swimming, sudden death in physical education, mountaineering exploration, etc.

1.4 Mental Health and Suicide Risk

Students' psychological crisis caused by academic pressure, emotional problems, Employment anxiety and so on led to suicide. Such security incidents accounted for a high proportion of College Students' abnormal deaths[3].

1.5 Laboratory and Internship Safety

Laboratory accidents: accidents caused by improper management of hazardous chemicals and equipment operation errors (such as deflagration and electric shock).

Internship/practice risk: due to the field investigation in distress, encountered overseas high salary scams and other illegal employment traps.

1.6 Public Health and Food Safety

Food poisoning: such as collective food poisoning caused by unqualified catering hygiene outside the school.

Spread of infectious diseases: influenza and other diseases spread due to intensive living in dormitories.

1.7 Extreme Weather and Natural Disasters

During the summer vacation, the students staying in school were affected by high temperature, heat

stroke, typhoon and flood, resulting in safety accidents.

2. The Pain Points of Current College Students' Safety Education

At present, there are many pain points in college students' safety education, which restricts the actual improvement of the education effect. Specifically:

2.1 The Education System Is Imperfect and Lacks Systematicness and Normalization

Safety education is not included in the regular teaching plan: safety education in many colleges and universities is only carried out in the form of temporary lectures, publicity posters and so on, which does not form an institutionalized curriculum system, resulting in scattered education content and lack of continuity.

The content of education lags behind and fails to keep pace with the times: the traditional safety education still focuses on basic fields such as fire protection and theft prevention, while the emerging risks such as network security, AI fraud and psychological crisis intervention are less involved or not deep enough.

Lack of standardized teaching materials and assessment mechanism: safety education in some colleges and universities relies on empirical explanation, lacks unified teaching materials, and does not establish an effective assessment system, resulting in low student participation.

2.2 Single Education Form and Lack of Practicality

2.2.1. it focuses on theoretical indoctrination and lacks practical exercises: the safety education in most colleges and universities still stays in classroom teaching, so it is difficult for students to really master practical safety skills such as emergency escape, self-defense, cardiopulmonary resuscitation, etc.

Insufficient application of new media: although college students generally rely on social media, college safety education is still dominated by traditional bulletin boards and class meetings, and fails to make full use of short videos, VR simulations, interactive games and other forms loved by students.

Lack of case teaching: safety education is more general and lacks in-depth analysis of real fraud cases, laboratory accidents and psychological crisis events, which makes it difficult for students to form a profound understanding.

2.3 Weak Faculty and Low Degree of Specialization

lack of full-time safety education teachers: most colleges and universities' safety education is held concurrently by counselors or security office personnel, who lack professional training and are difficult to systematically impart safety knowledge.

High mobility of teachers: because safety education has not been included in the teacher assessment system, the enthusiasm of relevant teachers is not high, and the team stability is poor.

2.3.3. insufficient integration of social resources: colleges and universities rarely introduce external forces such as public security, fire protection and psychological experts, resulting in the lack of practicality and authority of safety education.

2.4 Students' Weak Safety Awareness And Low Participation

The "it has nothing to do with me" mentality is common: some students think that safety accidents are small probability events, and they are perfunctory about safety education until they encounter fraud, fire and other events.

High risk behaviors continue despite repeated prohibitions, such as illegal use of electricity in dormitories, going out alone at night, credulous Internet part-time work, etc., reflecting the limited actual effect of safety education.

Insufficient ability to identify psychological crisis: college students lack awareness of psychological problems such as depression and anxiety, which leads to suicide and self injury from time to time.

2.5 The Management Mechanism Is Not Perfect and the Responsibility Is Not Fully Implemented

Multiple management with unclear responsibilities: the security office, the Department of study and work, the Youth League Committee and other departments are often responsible for the safety education in Colleges and universities, but they lack overall coordination and are prone to buck passing.

Hidden danger investigation and safety drill are mere formality: the safety inspection and safety drill in some colleges and universities only stay in the "walk through" and fail to really establish a closed-loop mechanism of "discovery rectification feedback".

2.5.3. lack of home school collaboration: parents pay low attention to their children's school safety issues, and schools also lack effective channels to transmit safety information to parents, which makes it difficult to prevent off campus risks (such as online loans and pyramid selling).

2.6 Insufficient Technology Empowerment and Lack of Intelligent Prevention and Control System

The campus security system is backward: some colleges and universities still rely on manual inspection and fail to fully apply AI monitoring, big data early warning, intelligent fire protection and other technical means.

Weak ability to identify online fraud: in the face of AI face-to-face fraud, phishing links, false recruitment and other new online crimes, students lack prevention awareness and effective prevention means.

3. EFFECTIVE MEASURES TO IMPLEMENT SAFETY EDUCATION FOR COLLEGE STUDENTS UNDER THE BACKGROUND OF

INTERNET

3.1 Build a Systematic and Normalized Safety Education System

First, a compulsory course of "safety education for college students" of 1-2 credits can be set up, with 8-10 class hours per semester, covering traditional safety (fire protection, traffic) and emerging safety (cyber fraud, AI risk), etc.

Second, design courses by grade: focus on fraud prevention and dormitory safety in the major, focus on internship and part-time safety in the sophomores and juniors, and strengthen employment legal risk in the senior.

Establish a school level safety education resource database, integrate the case materials of public security, fire protection, Internet information and other departments, and regularly update the new methods of online fraud (such as AI face-to-face fraud).

Make short videos, interactive games and other new media content, such as "deception prevention sitcom" and "security knowledge breakthrough app", to enhance students' participation.

3.2 Innovate Education Forms and Strengthen Practicality and Interactivity

Use virtual reality technology to simulate fire escape, phishing attacks and other scenarios, so that students can master emergency skills through immersive experience. For example, the development of "virtual fraud prevention laboratory" enables students to identify fraud scripts through simulated dialogue and improve their practical ability.

Organize campus security drills (such as anti-terrorism drill and cardiopulmonary resuscitation training), and cooperate with relevant departments to carry out the performance of "fraud prevention sitcom". Set up a "safety training camp" to teach students practical contents such as self-defense and first aid skills.

Establish an official account at station B, Douyin and other platforms, and release a series of videos of "one minute Safety Science Popularization"; Push personalized security reminders (such as anti trap guide during internship) through wechat applet.

3.3 Strengthen the Construction of Teaching Staff and Professional Training

First, set up a "safety education teaching and Research Office" to absorb the security office, psychology teachers, and experts outside the school (such as cyber policemen and firefighters) to teach together.

Second, carry out security education and training for counselors, focusing on improving the ability of online fraud identification and psychological crisis intervention.

We can cooperate with relevant authorities to set up a "security lecture hall", and regularly invite the personnel of the anti fraud center to analyze the latest cases.

At the same time, the joint venture develops a safety education platform, such as "safety micro companion" and other micro courses.

3.4 Optimizing Management Mechanism and Technology Prevention and Control

First, use big data to analyze students' online behavior (such as frequent login to gambling websites), trigger early warning and push customized safety education content.

Second, develop the campus security app, and integrate the functions of "one click alarm", "psychological assistance", "fraud reporting" and so on.

Attach "safety instructions" to the freshmen's admission notice, requiring freshmen to complete the online safety test. Parents regularly push safety tips (such as the holiday MLM Prevention Guide) to form a home school joint prevention mechanism.

Deploy AI monitoring system to automatically identify dangerous behaviors (such as illegal use of electricity in dormitories); Install intelligent power monitoring equipment to cut off overload circuit in real time to avoid safety accidents.

3.5 Focus on Emerging Risk Areas

Special courses such as "Ai face changing fraud identification" and "chatgpt false information identification" can be offered to improve students' safety awareness and ability.

Educate students to learn to protect privacy in the virtual world and guard against identity theft and social engineering attacks.

3.6 Improve the Assessment and Feedback Mechanism

Conduct online test (30%) and offline practice (70%) for the safety courses opened, and issue "safety literacy certificate" to the qualified.

Analyze the effectiveness of education regularly through anonymous questionnaires and online behavior data, and dynamically adjust the content. For example, compare the incidence of campus fraud cases before and after education, and the passing rate of students' network security knowledge test.

In short, through the implementation of the above measures, colleges and universities can build a full chain safety education mode of "prevention education intervention feedback", change the safety education from "passive response" to "active defense", and use Internet technology to achieve the education goal of wide coverage, strong interaction and precision, so as to effectively improve the safety literacy of college students in the digital age.

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Curriculum Reform of On-the-job Internship in Higher Vocational Colleges

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Abstract: This paper takes the on-the-job internship courses in higher vocational colleges as the research object, analyzes and discusses the problems existing in the teaching implementation process of these courses, and determines corresponding solutions, providing certain methods and ideas for the teaching of on-the-job internship courses.

Keywords: Higher Vocational Colleges; Internship; Solution Strategies.

1. INTRODUCTION

The internship course, as one of the compulsory courses in the mechanical major, occupies a very important position in the curriculum system and training program of major vocational colleges. The main task of this course is to enable students to adapt to the enterprise environment and working environment in advance through participating in internships, combine theory with practice, improve students' ability to analyze and solve problems, enhance their comprehensive quality, and prepare them for future work. However, due to the long duration of the internship course and the poor working environment in the workshop, there are significant difficulties for most students, and many students encounter various problems after only a few days of internship. The traditional internship model has problems such as emphasizing practice over learning and loose management, which make it difficult for students to effectively transition from learners to professionals. Based on this, it is necessary to reform the teaching process of the internship course[1] .

Exploration of teaching issues and causes in on-the-job internship courses The internship course is the last course before graduation. However, due to the long duration and poor working environment of this course, several issues have been identified during the implementation of the internship:

The cultivation of skills learned by students in school lags behind. Among mechanical engineering teachers, 43% have no work experience in enterprises, making it difficult for them to timely grasp technological changes in the industry. 63% of college courses are out of touch with enterprise production, with many technologies already lagging behind or even obsolete. The average course update cycle is 5.7 years, much faster than the 3-year technological iteration speed in the equipment manufacturing industry. At the same time, job adaptability is low. 32% of students report that the internship content is unrelated to their future career direction, such as numerical control majors being assigned to repetitive and monotonous tasks on the assembly line. In addition, the school-enterprise collaboration mechanism is ineffective, with only 18% of partner enterprises participating in course design, and most only providing internship opportunities in basic positions rather than technical positions. Due to technological confidentiality or cost considerations, enterprises often use interns as cheap labor, resulting in students gaining little[2-4] .

The dual-mentor system is a mere formality. Corporate mentors provide an average of less than 1.5 hours of guidance per week and have not undergone systematic teaching ability training, resulting in poor guidance effectiveness. Meanwhile, corporate safety training is lacking, with 56% of internship accidents stemming from the lack of pre-job equipment operation standard training, such as the 83% rate of accidental touch of the emergency stop button on CNC machines. Additionally, dynamic monitoring is absent, with only 9% of colleges and universities using digital management platforms, and most relying on spot checks of paper logs. The dispersion of internship positions leads to poor communication between teachers and students, insufficient self-management ability among students, and frequent safety hazards. Enterprises fail to provide professional training or equal pay for equal work, and some positions have high work intensity and low salaries[5] .

87% of assessments rely solely on final internship reports, neglecting the tracking of skill development. 52% of corporate evaluation forms exhibit a "favoritism" phenomenon, failing to reflect the true skill level. With a high proportion of only children, they struggle to adapt to high-intensity corporate management, and 40% terminate their internships prematurely due to stress. Some students respond negatively or frequently change positions due to cognitive biases towards internships. Additionally, data statistics and analysis pose challenges. When schools compile internship data, such as student internship position distribution, internship satisfaction, and corporate evaluations, it requires significant manpower and time, and the accuracy of the data is difficult to guarantee[6] . Due to the lack of effective data analysis, schools are unable to adjust teaching and management strategies in a timely manner based on internship situations, hindering the

improvement of internship course quality.

The implementation of industry-education integration policies is insufficient, and local governments have not included enterprise participation in curriculum development as a core indicator for the certification of industry-education integrated enterprises, leading to a lack of sustained investment motivation for enterprises. There are deviations in students' career cognition. According to a sample survey, 68% of mechanical engineering students still have expectations for their internships at the level of "observation and learning," lacking the awareness to actively participate in complex tasks. The average internship funding per student is less than 2,000 yuan per year, making it difficult to support high-cost training such as precision machining. The support system is imperfect, with work-related injury insurance coverage only reaching 59%. The lack of protection for student rights and interests exacerbates disputes between schools and enterprises.

In internships, the cultivation of professional ethics and skills is crucial. However, currently, some vocational colleges overly focus on enhancing students' professional skills, neglecting the cultivation of professional ethics. During the internship process, students lack in-depth understanding and practice of professional ethics, professional norms, and team collaboration spirit. For example, some students exhibit issues such as weak sense of responsibility, passive work attitude, and lack of teamwork awareness in their internship positions. This not only affects the evaluation of students by enterprises but also hinders their future career development. Meanwhile, in terms of professional skill cultivation, there is a gap between the internship guidance provided by schools and the actual needs of enterprises. The comprehensive practical and innovative abilities required by enterprise positions are not fully honed in internship courses, and students need a longer period of time to adapt to job requirements after entering the enterprise.

The current evaluation system for internship courses in vocational colleges has many flaws. Firstly, the evaluation subject is singular, primarily relying on the evaluations of enterprise mentors, with low participation from school teachers, neglecting students' self-evaluation and peer evaluation. This singular evaluation subject makes it difficult to comprehensively and objectively reflect students' internship performance. Secondly, the evaluation indicators are unscientific. Evaluation indicators often focus on students' completion of work tasks, with insufficient attention paid to students' professional quality improvement, learning ability enhancement, and innovative thinking cultivation during the internship process. For example, some schools only evaluate students' internship performance based on the quantity and quality of products produced in their internship positions, ignoring the abilities demonstrated by students in team collaboration and problem-solving processes.

2. TEACHING STRATEGIES FOR ON-THE-JOB INTERNSHIP COURSES

Based on the aforementioned issues, the corresponding teaching strategies are proposed as follows:

Promote local governments to introduce the "School-Enterprise Joint Training Points Management Measures", linking the depth of enterprise participation with tax incentives; establish a curriculum committee composed of deans of secondary colleges and technical directors of enterprises, set up an enterprise mentor allowance system, and require technical backbones to undertake no less than 80 hours of internship guidance per year.

Strengthen the management of the internship process and build an internship management mechanism that involves schools, enterprises, and students. Schools should arrange dedicated personnel to be responsible for internship management, communicate regularly with enterprises to understand students' internship situations. At the same time, each student should be equipped with an on-campus instructor and an enterprise mentor. The on-campus instructor should communicate with students regularly through a combination of online and offline methods to promptly solve professional problems and psychological confusion encountered by students during internships; the enterprise mentor should provide practical guidance to students on the job site to help them adapt to their work positions as soon as possible. Establish an internship information feedback platform, where students can provide real-time feedback on their internship situations, and schools and enterprises can obtain information in a timely manner and take corresponding measures. For example, a vocational college has developed an internship management APP, where students can submit weekly internship reports and feedback issues, and teachers and enterprise mentors can also provide guidance and evaluation to students through the APP, greatly improving the efficiency of internship management.

Develop a modularized curriculum system, where the basic module covers general abilities such as safety production norms and corporate culture cognition; the specialized module sets up subdivided job tasks according to the "1+X Certificate" standard (such as numerical control machining error analysis, e-commerce live broadcast operation); the innovation module is based on the joint incubation of technology improvement projects by schools and enterprises, and excellent achievements can be transformed into patents or process standards. Digital transformation empowers management, building a "Intern Brain" cloud platform to achieve face recognition attendance and work hour statistics; enterprise mentors annotate internship logs online; AI-based internship risk

warning (such as automatic reminder when job fit is less than 60%). Introduce blockchain technology to store internship achievements, ensuring that evaluations cannot be tampered with.

The construction of teacher teams implements the "Dual-Master Enterprise Workstation" plan, requiring professional teachers to take a 6-month off-the-job practice every 3 years; enterprise technical experts are included in the part-time teacher pool of colleges and universities, participating in the formulation of curriculum standards; a three-dimensional evaluation system of "college self-examination + third-party evaluation + enterprise feedback" is established. The course content is dynamically updated, and the internship course content needs to be updated in a timely manner. Schools and enterprises establish a regular communication mechanism, jointly pay attention to industry trends, and adjust course content in a timely manner according to changes in enterprise needs. This enables students to adapt to the market demand for new energy vehicle technology talents.

(4) Strictly screen internship units. Schools should establish a dedicated internship unit selection team and formulate strict screening criteria for internship units. When selecting internship enterprises, factors such as the enterprise's scale, industry influence, corporate culture, and safety production conditions should be fully considered to ensure that the enterprise can provide students with a good internship environment. At the same time, it is important to focus on the matching degree between internship positions and students' majors, to ensure that students can combine their learned professional knowledge with practice during the internship process. This will enable students to gain sufficient training during their internship.

3. CONCLUSION

The reform of on-the-job internship courses is not a mere adjustment of teaching formats, but a profound transformation of vocational education concepts. It necessitates a collaborative effort among institutions, enterprises, and students to forge a new ecosystem of industry-education integration. In the future, we should continuously explore new forms of internship courses in the "Smart+" era, such as virtual simulation internships, remote collaborative internships, and other models, ensuring that vocational education resonates with industrial development at all times

Based on some of the issues encountered during the teaching of internship courses, this article systematically analyzes the underlying reasons and proposes corresponding teaching strategies to provide some guidance for future teaching of internship courses.

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Misunderstanding and Disagreement: Analysis of the Conflict between Tao Chengzhang and Sun Yat-sen

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Abstract: In 1908, Tao Chengzhang was commissioned by the Guangfu Society to raise funds in Southeast Asia to address revolutionary challenges. However, due to economic constraints and political disagreements, his fundraising efforts failed. Tao later blamed Sun Yat-sen's interference and collaborated with revolutionary factions to publish the "Opinion Letter of the Seven Provinces' Revolutionary Alliance," accusing Sun of "crimes" and opposing his actions. While many initially dismissed these accusations as fabricated separatist motives stemming from fundraising disputes, historical analysis reveals that the conflict arose from mutual misunderstandings rather than malicious framing.
Keywords: Tao Chengzhang; Sun Yat-Sen; Anti-Sun Wind Trend; Conflict and Dispute;

1. INTRODUCTION

The "Sun Feng Movement" has long been a focal point in the study of Republican-era history and the Xinhai Revolution. The conflict between Tao Chengzhang and Sun Yat-sen during this movement has particularly drawn scholarly attention. With its profound historical impact, this event played a pivotal role in the split of the Tongmenghui and the subsequent setbacks in revolutionary progress. Therefore, examining the tensions between Tao Chengzhang and Sun Yat-sen holds significant value for understanding internal contradictions during the early stages of the bourgeois democratic revolution and for reconstructing the trajectory of the Xinhai Revolution.

At the current stage, there is limited academic research on the conflicts between Sun Yat-sen and Tao Chengzhang. Mr. Yang Tianshi's "History of the Republic of China" provided a brief account of these events. However, scholarly discussions have significantly expanded in recent years, with studies focusing on three main aspects: First, articles like Yang Tianshi's "The 'Anti-Sun Movement' and Chiang Kai-shek's Assassination of Tao Chengzhang," Peng Jian's "New Explorations on the Second Anti-Sun Movement," and Xie Yibiao's "The Entanglements Between Sun Yat-sen and Tao Chengzhang" analyze the relationship between Tao Chengzhang and the "Anti-Sun Movement," its impact on overseas Chinese communities, and whether the "Sun Wen crimes" allegations were substantiated. Second, Yang Tianshi's "The Split of the Tongmenghui and the Rebuilding of the Guangfu Association" and Yang Zhenhua's "Analyzing Sun Yat-sen's Character Weaknesses Through Tongmenghui Internal Disputes" examine their relationship from an organizational perspective. Third, works such as Sang Bing's "Idealism in Faith and Pragmatic Strategy: On Sun Yat-sen's Political Personality" discuss their contradictions through personality analysis.

In summary, academic research has predominantly focused on analyzing specific events and individuals to explain the conflicts between Tao Chengzhang and Sun Yat-sen, without systematically tracing the origins and evolution of their tensions. Many commentators still regard the "Anti-Sun Movement" as Tao's malicious defamation of Sun Yat-sen, viewing it as a detrimental act that divided the revolutionary cause. However, through comprehensive analysis, it becomes evident that their disputes primarily stemmed from accumulated misunderstandings and disagreements during the early stages of the revolution, which ultimately led to inevitable conflict due to inadequate organizational development.

Building upon previous research, this paper examines the character traits of Tao Chengzhang and Sun Yat-sen through their landmark conflicts. By analyzing Tao's personality traits, it reveals how their divergent political ideologies and organizational structures during the early bourgeois democratic revolution-characterized by underdeveloped leadership mechanisms-led to escalating misunderstandings. The study concludes that their irreconcilable differences, rather than Tao's alleged malicious attempts to undermine the revolution, ultimately resulted in inevitable conflict.

2. HIDDEN DANGERS BEFORE THE OUTBREAK OF CONFLICT

In 1904, Tao Chengzhang and Cai Yuanpei founded the Guangfuhui Society in Shanghai, with Cai serving as president and Tao as vice-president. After 1905, many members successively joined the Tongmenghui. At this time, there existed a situation where "most people in inland Zhejiang were unaware of the Tongmenghui's activities and still used its old name Guangfuhui" [11]. Initially, the two organizations operated independently without any connection. As

the revolution grew in scale, coupled with issues like lack of organizational structure and disciplinary constraints, both external observers and internal members became confused about the distinctions between these groups[1].

After joining the Tongmenghui, Tao Chengzhang became deeply committed to revolutionary causes and served as editor-in-chief of Japan's Minpao newspaper. During this period, Sun Yat-sen and other revolutionaries were waging armed uprisings in southern China, while the Tongmenghui headquarters remained in Tokyo. Tao maintained close ties with Sun Yat-sen. However, as the revolution progressed, significant conflicts arose between Tao and Sun, with financial issues at Minpao newspaper being the direct catalyst for their falling out.

During the activities of the League, its funds were mainly funded by enthusiastic revolutionaries. However, the funds needed for the revolution were often more than the amount raised, and there was a lack of specific regulations on the collection and distribution of funds within the revolution. Therefore, the problem of funds has always been a major contradiction and hidden danger in the development of the revolution.

In 1906, the Qing government formally requested the Japanese Cabinet to arrest and expel Sun Yat-sen from Japan, but under Japanese law at the time, such an expulsion was impossible. While anticipating Sun's potential future influence, the Japanese authorities ultimately decided to send him abroad with diplomatic courtesy due to repeated Qing demands and their own disapproval of revolutionary activities in Japan. Before his departure, the Japanese government hosted a farewell banquet for Sun Yat-sen and provided 5,000 yuan in travel expenses. Japanese merchant Suzuki Hisaburo also donated 10,000 yuan to him. Notably, the donation from the merchant was publicly announced, while the government's contribution remained largely unknown. This funding proved to be a timely lifeline for revolutionary organizations in their developmental phase. To fund the planned southern uprising, Sun Yat-sen accepted the grant. Prior to his departure, he allocated 2,000 yuan to Zhang Taiyan and Tao Chengzhang for operational costs of the People's Gazette, 1,000 yuan for a farewell banquet, with the remainder designated for revolutionary activities in Vietnam. Zhang Taiyan and Tao Chengzhang expressed dissatisfaction over what they perceived as an inadequate distribution. Subsequently, Sun Yat-sen departed Japan with Hu Hanmin and others for Southeast Asia.

At this critical juncture, Tao Chengzhang and Zhang Taiyan, editors of the People's Gazette, remained completely unaware of the Japanese government's donation of 5,000 silver dollars. Their organization faced persistent financial struggles, struggling to cover rent payments and operational costs. Despite multiple appeals to Sun Yat-sen for assistance, their pleas went unanswered. When they later discovered that Sun had accepted the Japanese grant and allocated 2,000 silver dollars specifically for the gazette's expenses, Tao and his associates condemned the allocation as unjustified, accusing Sun of misusing funds and accepting bribes that tarnished the reputation of the Tongmenghui (Alliance Society). This revelation culminated in Zhang Taiyan's proposal to dismiss Sun from his position as Premier, a move that gained support from some core members of the organization.

In 1905, Sun Yat-sen's successive failed uprisings reached Tokyo, further fueling the "anti-Sun Movement". However, Liu Kuiyi rejected the proposal to convene a new Premier election assembly, speculating that Sun might be using Japanese funding for covert planning[2]. Huang Xing also declined to serve as the Tongmenghui Premier. While the first wave of the movement subsided temporarily, tensions between the two factions remained unresolved.

Some scholars argue that Tao Chengzhang was a key figure in the first "Sun Yat-sen Censure Movement." However, Tao explicitly denied any involvement in the incident, stating in his "Letter to Comrade Bu Gao" that he never participated in discussions about "removing Sun Yat-sen" during this movement. Nevertheless, Tao's assertion that "Sun Yat-sen accepted bribes" aligns with other participants' claims regarding the Sun Yat-sen Censure Movement.[12]

3. OUTBREAK OF CONFLICT: THE EMERGENCE OF THE SECOND "SUN WIND WAVE"

After the first "reverse Sun wind wave", the contradictions became more and more fierce due to the lack of effective handling of conflicts, the lack of discipline and restraint of organizations, the defects in organizational construction, and the improper handling of conflicts by leaders, leading to the second "reverse Sun wind wave".

After Sun Quan's departure, the People's Gazette faced mounting financial difficulties. Zhang Taiyan repeatedly sought assistance from Sun Yat-sen but was unsuccessful. Meanwhile, the Tongmenghui's Nanyang branch and its Zhongxing Daily, as supporters of Sun Yat-sen, grew disillusioned with the Tokyo Tongmenghui due to the anti-Sun movement. Compounding these challenges, Zhang Taiyan's editorial focus on Buddhist philosophy in the People's Gazette clashed with revolutionary ideologies, causing its circulation to plummet and further exacerbating the newspaper's financial crisis.

Amid mounting economic hardships and setbacks in revolutionary efforts, Zhang Taiyan was compelled to dispatch Tao Chengzhang to Southeast Asia for fundraising. Sun Yat-sen, however, opposed the plan, arguing that the region lacked sufficient economic resources, had few comrades, and no established capitalist networks. He instead advocated for independent fundraising within Tokyo. Ultimately,

Tao Chengzhang and his team rejected this proposal.

To further raise funds, Tao Chengzhang organized activities under the banner of the Restoration Society. However, due to the lack of support from Sun Yat-sen and others, coupled with the limited influence of the Restoration Society, the fundraising efforts ultimately failed. Meanwhile, Zhang Taiyan was fined 115 yuan by Japan and threatened with imprisonment in Tokyo if he failed to pay within the deadline. Fortunately, through the financial support raised by colleagues from Sichuan, Hubei, and Jiangxi provinces, as well as Tao Chengzhang's own contributions, he was spared from imprisonment[3].

During his travels, Tao Chengzhang met Li Xiehe, Liu Pinong, Hu Guoliang, and others. Through their interactions, he discovered that "like-minded individuals often exchanged subtle remarks"[13]. After Tao's investigation, he concluded that such slander "could not have arisen without cause." Consequently, Li Xiehe and Hu Guoliang drafted the "Public Address by Members of the Seven Provinces Alliance" and entrusted Tao to deliver it to Tokyo for public deliberation.

The public notice accused Sun Wen of seven "charges", a total of 14 items, that he had done nothing at the beginning of the establishment of the Tongmenghui, had no power in Guangdong and Guangxi, and had obtained the position of prime minister by fraud, and demanded that he be removed from office.[3]

After submitting the "Public Notice" to Huang Xing, the Chief Secretary, Tao Chengzhang requested convening provincial officials for consultation. Huang Xing deemed the document unsubstantiated and inappropriate for public disclosure, writing to Tao with the intention of having him "elaborate through his writings." Tao firmly rejected the proposal, asserting that such matters required collective deliberation. Following fruitless debates, Huang Xing rallied allies to petition Tongmenghui members in Southeast Asia, urging them to reflect on their stance. Meanwhile, Tao Chengzhang, sensing growing divisions within the organization and weakening morale, began preparing to break away from the Tongmenghui and independently publish his own "Public Notice."[4]

4. THE DEVELOPMENT OF THE CONFLICT BETWEEN TAO CHENGZHANG AND SUN YAT-SEN

In November 1909, the Nanyang General Gazette published an article titled "The Nanyang Revolutionaries 'Accusation of Sun Yat-sen's Crimes: The Opinions of the Seven Provinces Alliance," which became widely known as the "Opinions of the Seven Provinces Alliance."[5] Drafted by Tao Chengzhang, Li Xiehe, and others, the article was printed by Chen Weitao and distributed to newspapers across various ports.

In this conflict, Tao Chengzhang identified three major crimes against Sun Yat-sen: "five acts of harming comrades," "three acts of deceiving comrades," and "four acts of tarnishing the collective reputation," totaling twelve charges. He demanded that "Premier Sun Yat-sen's name be expelled, his crimes publicly disclosed, and the information disseminated worldwide."[14]

The charges listed in the article are mostly economic crimes against Comrade Sun Yat-sen, among which the primary issue is the accusation of embezzling public funds. It is believed that Sun Yat-sen and others embezzled more than 300,000 yuan during the Hekou uprising.

In response to the allegations, the Revolutionary Alliance conducted an investigation in his hometown and found no other assets beyond several old houses, thereby dispelling the so-called "rumors." The Vietnam Revolutionary Party also issued a "Hanoi Official Letter" to refute Tao Chengzhang's slander with factual evidence. Huang Xing took the initiative to address the negative impact caused by Tao Chengzhang's public letter through correspondence with overseas Chinese in America.[15] To counter this, Huang Xing collaborated with others to publish multiple articles in "China Daily" and "New Century" newspapers to refute Tao Chengzhang and his associates. In response to the criticisms from party members across different regions, Tao Chengzhang issued a "Comrade's Declaration" to address the accusations.

In response to the allegations, Sun Yat-sen adopted a markedly different approach from his previous stance of ignoring disputes and acting unilaterally. He wrote to Wu Zhihui explaining the economic issues raised by Tao Chengzhang and published clarifications in the 115th issue of New Century.[6] When Sun discovered that overseas Chinese in America were being affected by Tao's accusations, he immediately instructed New Century to publish an open letter to four major U.S.-Spanish newspapers and three Honolulu-based publications, denouncing Tao as "jealous of achievements, obsessed with fame, and driven by self-interest," urging media outlets to provide impartial explanations to foreigners. Meanwhile, Sun's supporters actively joined the debate. Hu Hanmin wrote to Nanyang comrades, calling Tao Chengzhang the "mastermind" behind the internal conflict, harshly criticizing him for "pursuing profit at the expense of righteousness and undermining collective interests through personal gain."[16] Eventually, Tao Chengzhang realized the errors of his actions and ceased attacking Sun Yat-sen.

Throughout the revolutionary process, Sun Yat-sen exhibited certain shortcomings, including insufficient tolerance in daily interactions, inadequate consultation with comrades, and insufficient promotion of democratic practices. These factors collectively led to misunderstandings. Meanwhile, Tao Chengzhang's misinterpretation of Sun Yat-sen,

their differing personalities, and political disagreements were the key factors that caused the conflict.

Obviously, the publication of highly biased and personal articles such as "The Public Notice of the Members of the Seven Provinces Alliance" had a bad influence, which not only brought inestimable losses to Sun Yat-sen, Tao Chengzhang, other participants and even the revolutionary construction.

5. ANALYSIS OF THE CONFLICT BETWEEN TAO CHENGZHANG AND SUN YAT-SEN

The wave of the revolution of 1911 swept across the country, and the establishment of the Republic of China marked a new chapter in history. At this historical juncture, the conflict between Tao Chengzhang and Sun Yat-sen was temporarily put aside due to the urgent situation, although it was not completely resolved.

Examining the entire historical development, their political ideologies served as a key catalyst for conflict. Sun Yat-sen focused on launching uprisings, establishing military forces, and building anti-Qing armed groups, while Tao Chengzhang prioritized propaganda strategies through covert methods like assassinations and violent demonstrations. These ideological differences, strategic divergences, personality clashes, and communication gaps gradually sowed the seeds of discord within the Tongmenghui. Consequently, when confronted with the financial struggles of Min Bao (The People's Gazette) and the failure of revolutionary uprisings, both factions found themselves in dire straits.

Sun Yat-sen still persisted in the uprising, trying to promote the revolutionary process by raising funds and strengthening military forces. Tao Chengzhang, on the other hand, may have been dissatisfied with Sun Yat-sen's economic management and gradually became dissatisfied and questioned him on the basis of his doubts about Sun Yat-sen's economic management.

Furthermore, the two leaders held differing political views regarding military affairs and constitutional monarchy. Militarily, Tao Chengzhang advocated for "preferring fewer but superior weapons," while Sun Yat-sen insisted on "more arms at lower costs to boost national prestige." Their ideological differences led to intense debates that ultimately caused their estrangement. On constitutional governance, Sun proposed establishing a "constitutional monarchy" through "political revolution," which Tao opposed, arguing that "monarchic systems inherently have flaws-whether constitutional or republican, they inevitably allow minority interests to prevail, leaving common people to endure hardships."[7]

The differences deepen without effective communication and understanding, and gradually evolve into public accusations and confrontation, personal grudges and opposition.

Meanwhile, the personalities of both individuals were crucial factors contributing to their conflicts. Tao Chengzhang's straightforward and principled nature often led to tense relationships due to disagreements and blunt remarks. Additionally, he exhibited stubbornness and limited tolerance. As Zhang Taiyan once commented on Tao: "He is impatient and incompatible with the Tongmenghui members."[17] Tao himself admitted: "My mind is inherently hasty, lacking tolerance for others' faults. Recently, my suspicions have multiplied-this is not what I should be like, yet humiliation and danger have come knocking."[18] Chen Qimei criticized him for "ignoring the bigger picture," a tendency clearly demonstrated by his repeated public accusations against Sun Yat-sen[8].

Sun Yat-sen's revolutionary journey epitomized the paradoxical unity of idealism and pragmatic strategy.[9] This ideological-legalistic tension often created contradictions between his actions and stated principles, leading to accusations of unethical tactics and public misinterpretation. A notable example is Tao Chengzhang's accusation that he issued military bonds during fundraising, tarnishing the party's reputation.[10] Sun's authoritarian personality further exacerbated tensions. When the "Anti-Sun Movement" reached its peak, Liu Kuiyi advised resignation to "quell public anger," but Sun insisted that "party disputes should be resolved through facts, not personal accountability"[19], requiring both organizational approval and Zhang Taiyan's own confession. Instead of addressing conflicts through dialogue, Sun adopted a confrontational stance, later establishing the Nanyang Branch as a rival center to distance itself from the Tokyo headquarters. These actions not only failed to resolve issues but also deepened divisions and discontent within the organization.

It is precisely these differences and conflicts, like a "touchstone", that do not make the revolution die in division, but make the revolution gain new life in challenge, and make the revolutionaries realize the importance of communication and understanding, organization and construction, and unified thinking.

6. CONCLUSION

The seeds of conflict between the two individuals had already begun to take root during the early stages of the "Reverse Sun Wind Movement". Their political disagreements first surfaced over the allocation of funds for the People's Gazette. As misunderstandings and differences persisted without proper resolution, they gradually intensified. Amidst the challenges of the early revolutionary period, these tensions escalated into open confrontation, ultimately evolving into a full-blown clash.

After the storm of political upheaval subsided, Tao Chengzhang came to recognize his mistakes. He reevaluated his actions and ceased conflicts with Sun Yat-sen, joining forces in revolutionary endeavors. Together, they participated in numerous pivotal

decisions and campaigns following the Xinhai Revolution, including the Northern Expedition and the Constitutional Protection Movement. Their joint efforts played a crucial role in overthrowing the Beiyang warlords' rule and preserving the republican system.

Tao Chengzhang was a pioneer in revolutionary movements and a modern-day advocate for democracy. As an anti-Qing patriot, Tao Chengzhang made significant contributions to advancing bourgeois democratic revolution and promoting public engagement. While his revolutionary activities contained some imperfections, his fundamental stance remained clear: he championed anti-feudalism, championed democratic revolution, and[20] made crucial contributions to revolutionary development. His unwavering loyalty and passion for the cause are beyond question. Sun Yat-sen once praised him, stating: "For over a decade, Mr. Tao has dedicated himself to revolutionary causes, tirelessly mobilizing efforts," and "his contributions are truly monumental." Tao Chengzhang was a pioneer of the revolutionary movement and a modern-day advocate for democracy. As an anti-Qing patriot, Tao Chengzhang made significant contributions to advancing bourgeois democratic revolution and inspiring public engagement. While his revolutionary activities contained some imperfections, his fundamental stance remained clear: he championed anti-feudalism and prioritized democratic revolution, ①making substantial contributions to revolutionary endeavors. His unwavering loyalty and passion for the cause are beyond dispute. Sun Yat-sen once praised him, stating: "For over a decade, Mr. Tao has dedicated himself to the revolutionary cause with tireless effort," adding that he "has indeed achieved monumental feats." So we should not erase all the achievements of his revolution because of his temporary mistakes[21].

In conclusion, the "Sun Fengchao Rebellion" as a significant historical event during the Xinhai Revolution not only revealed personal conflicts between Tao Chengzhang and Sun Yat-sen, but also demonstrated ideological clashes among revolutionaries regarding revolutionary strategies. This phenomenon highlighted the evolution of revolutionaries through challenges and their eventual transformation. The rebellion's emergence and development constituted a complex process, resulting from intertwined political dynamics, ideological differences, individual personalities, and mutual misunderstandings. It should not be simplistically labeled as a premeditated act of undermining the revolution.

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Epidemic Epidemics and Social Responses in Qiannan West Prefecture during the Early Period of New China's Establishment (1950—1956)

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Abstract: In the early days of the founding of New China, the Qianxinan region faced a severe epidemic situation. Due to historical legacy of backward medical and health conditions, lack of scientific epidemic prevention awareness among the public, coupled with complex terrain and poor transportation infrastructure, infectious diseases such as malaria, dysentery, and smallpox frequently occurred, posing serious threats to people's health and social stability. The government gradually established a public health prevention and control system through measures including establishing grassroots health organizations, launching patriotic hygiene campaigns, implementing free vaccination programs, and dispatching medical teams to rural areas. Combined with public mobilization for environmental remediation and epidemic prevention publicity, this process demonstrated the integration of national power decentralization and the mass line. Not only did it effectively control the epidemic, but also laid the foundation for health modernization in ethnic minority regions, showcasing the practical characteristics and historical significance of public health governance in peripheral areas during the early days of New China's establishment.

Keywords: Qiannan West Prefecture; Epidemic; Social Response

1. INTRODUCTION

Epidemics are contagious diseases that spread through populations. Humanity's struggle against epidemics has a long history. Epidemics, wars, and famines are collectively known as the "three deadly threats" of human history. These scourges often strike simultaneously, ravaging societies with their devastating impact—not only causing suffering and panic but also potentially leading to societal collapse or even national extinction.[11] During an epidemic outbreak, "it can result in mass deaths, urban devastation, political collapse, the disintegration of nations and civilizations, and even the annihilation of entire ethnic groups or species." [12] This demonstrates that epidemics not only threaten individual health and lives but also significantly influence a nation's political stability, economic development, cultural preservation, military preparedness, and overall social progress.

In the early days of the establishment of New China, the Party and the state placed great emphasis on epidemic prevention and control. The relationship between disease outbreaks, prevention and control, and society and the nation has drawn attention in academic circles. [13] In recent years, Guizhou Province, due to its unique topography, climate, and environment, has become a convergence point for various diseases. The epidemiology and prevention of diseases in Guizhou have also attracted scholarly attention. [14] Regarding the overall research on disease outbreaks in Guizhou, on one hand, more focus has been placed on the Anti-Japanese War period, while studies after the establishment of New China remain relatively scarce. On the other hand, there is insufficient attention to the epidemiology and prevention of diseases across various regions under Guizhou's jurisdiction.

Therefore, this paper approaches the subject from the perspective of epidemic prevention and control, focusing on the epidemiological trends and social responses in Qiannan Prefecture during the early years of the People's Republic of China. On one hand, it examines the Chinese Communist Party's grassroots development and governance through the lens of epidemic prevention. On the other hand, it further explores historical materials related to modern and contemporary history and epidemic patterns in Qiannan Prefecture and even Guizhou Province, addressing gaps in existing research while providing valuable historical references for contemporary epidemic prevention efforts.

2. THE EPIDEMIC AND HARM OF DISEASES IN QIANXINAN PREFECTURE DURING THE EARLY ESTABLISHMENT OF NEW CHINA

Qianxinan Buyi and Miao Autonomous Prefecture (abbreviated as Qianxinan Prefecture) is one of the nine prefecture-level administrative regions in Guizhou Province, situated in southwestern Guizhou at the southeastern end of the Yunnan-Guizhou Plateau. Its jurisdiction encompasses Xingyi City, Xingren City, Anlong County, Zhenfeng County, Qianlong County, Pu'an County, Wangmo County, and Ceheng County, comprising two cities and six counties in total.

The complex terrain and climate of Qiannan Prefecture constitute key natural factors contributing

to disease outbreaks in the region. The area features dramatic topographical variations, encompassing diverse landforms such as mountains, plateaus, basins, and hills with highly transitional characteristics. This rugged topography results in significant heterogeneity in soil types and vegetation distribution, which while enriching local biodiversity, also provides multiple vectors for pathogen breeding and transmission. Climatically, the complex terrain creates pronounced vertical variations and regional climate fluctuations, as captured in proverbs like "No three consecutive days of clear skies, no three straight miles of flat ground" and "Sunlight at dawn, rain by dusk"[1]. While this variability offers suitable living conditions, it simultaneously fosters bacterial proliferation.

The region is located in the remote mountainous areas of the southwest, where the development of healthcare has always been relatively underdeveloped. In terms of staffing at health institutions, "In 1950, when the county people's government took over the health center, there was only 1 physician, 2 mid-level technicians, and 1 junior staff member" and "In 1952, there were 3 physicians, 11 mid-level technicians, and 6 junior staff members"[2]. Such staffing was far from sufficient to meet local medical demands. Regarding funding, after the establishment of New China, health funds were primarily allocated by county (city) finances. However, as the regions had just been liberated at that time, everything was in need of revival, and all construction projects depended on fiscal support, resulting in extremely limited actual funding for healthcare services.

Qianxinan Prefecture is located in the remote mountainous areas of southwestern China, with a large number of ethnic minorities and extremely backward cultural education. The ideology of feudal superstition still persists among the populace. In the early days of the founding of New China, when people fell ill, they did not seek medical treatment but instead turned to "Miao Bao" for "Miao medicine." Besides consulting "Miao Bao," some people would also seek witches to perform "soul-calling rituals." In addition to "soul-calling," there were also practices like "exorcism" and "spoon-erecting rituals." The ethnic minorities referred to "exorcism" as "dialing the old demon." "People in the county would invite witches with money, white and blue cloth, a rooster, and other items to perform rituals. They would chant incantations while placing a small jar containing 'ghosts' and sealing it with talismans before sending it to the outskirts." "Spoon-erecting rituals" involved "sudden illness attributed to the wandering spirits. Three chopsticks were placed together in a half-bowl of water, and the deceased's name was called aloud. If the sick person was found by the deceased, they would be given no water or food after the ritual to ensure recovery"[15]. In addition to these feudal superstitious practices, there were also initiatives like erecting road markers to protect frail children from disease and building bridges to help middle-aged and elderly people avoid illness.

In addition to the existence of superstitious beliefs, the epidemic prevention awareness and hygiene habits of the people in Qiannan West Prefecture were generally poor. "Li Dequan, Minister of Health of the Central People's Government, once pointed out at the 1950 National Epidemic Prevention Work Conference that the reason why a large number of diseases had long existed in China and harmed the Chinese people was mainly due to poverty, ignorance, poor environmental sanitation caused by reactionary rule, and low awareness of hygiene and poor personal hygiene habits."[3] The local indiscriminate disposal of garbage, preference for drinking raw water, consuming wild animal meat and rotten meat, and public urination and defecation all reflect the insufficient awareness of hygiene among the people and the lack of established epidemic prevention concepts and habits, which also served as important reasons for the spread of epidemics.

In the early days of the establishment of New China, Qianxinan Prefecture experienced "epidemic outbreaks"[4], with all counties witnessing disease outbreaks. On one hand, this indicates that the epidemic spread throughout the entire prefecture rather than being confined to a single county, demonstrating that the disease spread rapidly across different regions. The existing healthcare conditions were unable to keep up with the epidemic's transmission speed, reflecting the strain on local medical resources. On the other hand, although almost every county in the prefecture experienced annual outbreaks, the severity and types of epidemics varied significantly. For instance, Xingyi had only 2 measles cases in 1953, while Zhenfeng reported as many as 527 cases with 41 deaths. Clearly, epidemics shared common temporal and spatial characteristics across different regions, yet each area exhibited unique patterns in specific epidemic types.

In the early days of the new China, in the Qianxinan Prefecture, among the 14 infectious diseases specified by the Southwest Administrative Region Health Department, except for a few epidemic diseases such as scarlet fever and cholera, all others were prevalent and spread. Some even occurred annually, such as measles, typhoid, and paratyphoid. This demonstrates the complexity of local epidemic diseases, which posed significant threats to public health, life safety, and production and living activities.

Professor Jin Shiyi of Southern Medical University stated in the preface to Deng Tietao's "History of Epidemic Prevention in China": "Epidemics are the diseases that pose the greatest threat to human health"[5]. The shadow of death threats brought by epidemics loomed over the people. In the early days of the new China, epidemics continued to spread incessantly in Qiannan West Prefecture, with people losing their lives to diseases every year. For instance, during the six years from 1950 to 1955 in Xingyi City,

there were 314 total cases of smallpox with 50 deaths, resulting in a mortality rate of 15.92%. On December 11,1952, according to the regional epidemic report: "In Pengzha District, typhus fever was severely prevalent, with thousands of cases reported and five deaths occurring in one household"[16]. This demonstrates that epidemics constitute a major threat to human life and health.

The pandemic has caused massive casualties, drastically reducing the workforce and productivity, which directly impacted social production development. Moreover, the disease's harm extends beyond physical health to psychological trauma. In severely affected areas, "houses collapsed, farmlands lay fallow, families were torn apart, and once-thriving villages became desolate ruins"[6]. These developments have triggered widespread panic among communities.

In the early days of the new China, the epidemic caused severe physical and mental harm to the people and seriously hindered the progress of socialist construction. For the newly established people's government, epidemic prevention and control was a major challenge at the time. How to carry out epidemic prevention work and how to safeguard people's health and lives were urgent issues that needed to be addressed by the people's government.

3. RESPONSE TO EPIDEMIC PREVENTION AND CONTROL IN QIANNAN WEST PREFECTURE DURING THE EARLY PERIOD OF NEW CHINA'S ESTABLISHMENT

After the establishment of New China, under the premise that the Guizhou Provincial Government established the Provincial Health Department, various regions in Guizhou began to set up relevant health administrative institutions. The counties of Qiannan Prefecture also followed suit and successively established health administrative departments. For example, Xingyi County: "After the peaceful liberation of Xingyi in 1949, on March 17,1950, the county health center was managed by the county civil affairs department. In March 1952, the county government established a health section. In 1953, the county health section merged with the county culture and education section to form the county cultural and health section"[17]. Apart from Xingyi, all other counties in Qiannan Prefecture had established health sections during the early period of New China's founding to administer medical services. This not only provided leadership and organizational guarantees for the smooth implementation of epidemic prevention work in Qiannan Prefecture but also reflected the strong control of the Central Committee of the Communist Party of China over local governance.

To ensure the development of healthcare services and establish a comprehensive medical protection network, Qiannan West Prefecture not only established county-level hospitals but also continuously strengthened its medical institutions at all levels. Health centers and clinics were set up in each district and township within counties. However, due to underdeveloped grassroots health organizations that hindered routine epidemic prevention, the establishment of epidemic prevention teams became the primary approach. In August 1950, the Central People's Government's Ministry of Health mandated that all major administrative regions and provinces prioritize endemic diseases in their administrative plans, requiring the immediate establishment of epidemic prevention teams. It also instructed the creation of specialized training and research institutions for diseases like plague, kala-azar, leprosy, and malaria based on regional outbreaks[18]. Beyond county-level teams, district and township-level epidemic prevention groups and officers were established to conduct disease surveillance, provide treatment, and report outbreaks.

To effectively implement epidemic prevention measures and improve the public health system, it is essential not only to establish and enhance medical institutions but also to rely on the active cooperation of the general populace. Given the widespread low educational levels among the people at the time, prevalent superstitious beliefs, and poor living habits developed through prolonged exposure to harsh environments, comprehensive public education campaigns were crucial to promote hygiene knowledge. "As a political party with ideological consciousness, enlightening and educating the masses, disseminating our principles, and guiding voluntary compliance remains an unwavering commitment of the Chinese Communist Party"[7]. Through continuous epidemic prevention publicity, many residents gained enhanced awareness and better understanding of diseases. For instance, in Zeheng County's malaria treatment efforts, urban and rural communities utilized lantern-based mini-lectures, microscope demonstrations, physical exhibits, and small-scale health book exhibitions integrated with agricultural activities. This approach not only ensured smooth implementation of investigation and treatment but also transformed local sanitation conditions, fostering closer community engagement.

In addition to establishing and improving the public health system in Qiannan Prefecture, the Party and the state vigorously promoted public health governance. Firstly, they implemented planned immunization programs. Through provincial coordination and mobilization efforts, all counties in Qiannan Prefecture successively launched vaccination campaigns. Led by county governments, medical personnel from county, district, township, and village levels were organized to conduct nationwide immunization. Considering the region's geographical, residential, and transportation conditions, free immunization services were provided for various vaccine types. This gradually convinced many initially resistant or hesitant residents to actively participate. Taking Anlong County as an example: "From 1950 to 1955,186,385 people received smallpox vaccines, 7,925 received typhoid vaccines, and 926 received whooping cough

vaccines. After the establishment of the county epidemic prevention team in December 1956, dedicated health workers conducted mobile vaccination campaigns across the entire county." This represents a significant increase compared to the county's previous vaccination figures: "In 1948 (the 37th year of the Republic of China), 13,595 people received cowpox vaccines and 6,372 received typhoid vaccines"[19].

Secondly, the implementation of patriotic hygiene campaigns. Firstly, following the directives from Guizhou Provincial Patriotic Health Committee and in accordance with the "Organizational Guidelines for Patriotic Health Committees at All Levels in Guizhou Province," counties, government agencies, industries, and communities across Qiannan Prefecture established Patriotic Health Campaign Committees, branches, and sub-branches. Additionally, "each branch formed health task forces, integrating all government staff and citizens into organized participation"[20], ensuring nationwide engagement. Secondly, environmental sanitation improvement became a key mission for both Qiannan Prefecture and Guizhou Province. Counties conducted garbage clearance, house and street cleaning, improved human-animal cohabitation environments, eliminated disease vectors like mosquitoes and flies, filled sewage pits, and dredged drainage channels. Thirdly, democratic evaluations were implemented based on campaign progress and production activities. By cultivating exemplary models and recognizing outstanding regions, units, and individuals, this approach motivated public participation while shaping social values—clarifying what role models should embody and how proper conduct should be demonstrated. Through such progressive ideological education, the campaign aimed to reform customs and achieve national rejuvenation. Finally, public awareness campaigns emphasized Lenin's principle: "We must constantly and objectively examine our connection with the masses and its closeness. Only through such engagement can advanced groups educate and inspire the people, represent their interests, organize them effectively, and ultimately achieve comprehensive societal transformation."

"Party activities proceed along the path of conscious class policy"[8]. Without hindering production, they combine the interests of the masses and use vivid and personal examples to inspire their enthusiasm and initiative, so that propaganda work can proceed smoothly.

In the early days of the new China, facing a complex situation of external threats and internal challenges, the Communist Party of China strengthened its control over grassroots levels across various regions by establishing and improving the public health and epidemic prevention system, implementing planned immunization programs, and promoting patriotic hygiene campaigns to accelerate the development of mass movements. This demonstrated its crucial role in reforming social customs and transforming the nation.

4. THE EFFECTIVENESS AND SHORTCOMINGS OF EPIDEMIC PREVENTION AND CONTROL IN QIANXINAN PREFECTURE DURING THE EARLY ESTABLISHMENT OF NEW CHINA

In the early days of the new China, with the implementation of epidemic prevention and control efforts in Qiannan Prefecture, the spread of diseases was contained, mortality and morbidity rates continued to decline. Epidemic prevention institutions were gradually established, the epidemic prevention system was continuously improved, and the physical fitness and health awareness of the public also steadily increased. In addition, through these epidemic prevention initiatives, there has been a significant improvement in public recognition of the government and patriotic consciousness.

By comparing the outbreaks and mortality rates of various diseases in different regions of Qiannan Prefecture before and after the establishment of New China, it can be seen that prior to the founding of New China, infectious diseases not only had high incidence rates, often spreading from one infected individual to entire families or even entire villages. Due to medical shortages and improper treatment after infection, the mortality rate was also extremely high. However, after the establishment of New China, the incidence and mortality rates of many infectious diseases were significantly reduced, with some severe infectious diseases being virtually eradicated, demonstrating remarkable achievements in epidemic prevention and control.

In the early days of the new China, to address the continuous outbreaks of epidemics across various regions, organized mobilization efforts were implemented to integrate health services into grassroots governance and social networks. In March 1953, "the Guizhou Provincial Health Work Conference listed the establishment of health and epidemic prevention institutions as one of its six major tasks for that year, leading to the commencement of establishing health and epidemic prevention stations throughout the province"[9]. Under a series of policy guidance, Qiannan Prefecture "established regional hospitals and seven county hospitals between 1952 and 1956, while epidemic prevention and healthcare institutions in each county and district health centers were also successively set up. By the end of 1956, the number of medical institutions had reached 75"[10]. This demonstrates that the construction of grassroots health organizations and the hierarchical health and epidemic prevention system were continuously being established and improved.

In the early days of the establishment of New China, under the leadership of the Party and the state, Qianxinan Prefecture implemented various measures to combat epidemics and carried out health and epidemic prevention work. These efforts enabled the public to gain new understanding of the new regime and the Communist Party of China, shaping a fresh image of the CCP in people's minds, strengthening

public recognition of the government, while continuously enhancing patriotic awareness. The newly established people's regime was thus consolidated.

In the early days of the new China, Qianxinan Prefecture did achieve some remarkable results in epidemic prevention and control. However, due to insufficient institutional development, resource shortages and uneven distribution, backward medical technology, and limitations imposed by local social conditions, the region's epidemic prevention and control still faces significant shortcomings.

On one hand, in the early days of the new China's establishment, although under the leadership of the central and provincial governments, a health administration system and a tiered health epidemic prevention system were gradually established, the delayed information transmission and implementation led to the slow establishment of county-level epidemic prevention stations in Qianxinan Prefecture despite having epidemic prevention teams. By 1956, only about half of the counties and districts in Qianxinan Prefecture had established health centers. If even this was the case, it was even more challenging in remote rural areas. Therefore, although the health epidemic prevention system was continuously being established and improved during this period, its foundation remained relatively weak.

In addition to the weak health and epidemic prevention system, the medical technology in Qianxinan Prefecture was also relatively backward in the early days of the establishment of New China. When the Niuchang District Health Center in Zhenfeng County was established in 1953, it was described as "having only one medical kit per person, with no buildings or equipment available"[21]. The lag in medical technology wasn't limited to equipment shortages; the lack of professional competence among healthcare workers was also a key factor contributing to this backwardness. During the patriotic health campaign in Qiannan West Prefecture at that time, issues such as "health workers' inadequate understanding of comprehensive anti-malaria measures, reliance solely on medication while neglecting mosquito eradication, or overemphasizing chemical insecticides during extermination efforts while overlooking the elimination of breeding conditions"[22] emerged.

It is evident that the weak public health and epidemic prevention system, coupled with the lagging medical technology, has resulted in numerous challenges for Qianxinan Prefecture in disease control during the early stages of New China's establishment. Although the epidemic situation has improved over the years through governance efforts, some diseases still occur sporadically. Moreover, when sudden epidemics emerge, the local response speed and medical treatment capabilities remain insufficient.

On the other hand, prevention and control policies lack sustainability. The health and epidemic prevention work in Qiannan West Prefecture achieved certain results during the early establishment of New China, which is undeniable. However, under the short-term reduction of incidence rates and mortality rates of various infectious diseases, local health development has also fallen into a dilemma of sustainable development.

In the early days of the new China, the national economy was already strained, with limited funds being primarily allocated to industrial production. With insufficient funding for public health initiatives, local finances gradually became unsustainable in conducting regular patriotic hygiene campaigns. Moreover, as these campaigns progressed, public fatigue emerged, leading to situations where people remained inactive unless direct administrative orders were issued. All these factors indicate that the normalization of hygiene campaigns faced fundamental challenges and struggled to sustain development.

The engagement of cadres and residents in Qiannan Prefecture demonstrates notable passivity and superficiality. While some regions have achieved effective policy implementation, many local leaders remain largely passive in their duties. Post-mobilization campaigns still reveal persistent issues such as non-compliance with medication schedules, public urination and defecation, and inadequate personal hygiene practices. This participation pattern relies heavily on external mobilization efforts rather than fostering internal motivation.

5. CONCLUSION

In the early days of the People's Republic of China, Qianxinan Prefecture effectively curbed disease outbreaks in epidemic prevention and control. The health administration and epidemic prevention systems were gradually improved, while local residents' awareness of health protection, sense of government recognition, and patriotic consciousness continued to rise, contributing to the consolidation of the new regime. However, challenges remain such as the still weak epidemic prevention system, resource shortages with uneven distribution, and unsustainable policies and measures. Only by leveraging strengths and addressing weaknesses can we further advance the high-quality development of public health services under the backdrop of modernizing national governance, thereby safeguarding people's lives and safety.

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Patient Capital and Corporate Financialization

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Abstract: This study uses data of Chinese A - share listed companies from 2011 to 2024 to explore patient capital's impact on corporate financialization. Theoretical analysis shows patient capital can significantly inhibit corporate financialization. Mechanism tests reveal it curbs corporate financialization by reducing internal expected performance pressure. Heterogeneity analysis finds that the governance effect of patient capital is more prominent in enterprises with high information transparency, and those located in the central and eastern regions of China. This study provides a new theoretical explanation and empirical evidence for patient capital to inhibit enterprises' "shift from real to fictitious" and serve the real economy. It has implications for the transformation and upgrading of the economic structure and high-quality development, and also offers references for improving capital market governance and formulating policies.
Keywords: Patient Capital; Corporate Financialization; Internal Expected Performance Pressure

1. INTRODUCTION

In recent years, a large number of non-financial enterprises in China have gradually deviated from the operational path of the real economy and continuously allocated funds to financial assets and real estate, leading to an obvious trend of the macro-economy “shift from real to frictitious”. Excessive financialization of real enterprises will not only occupy the resources of their main business and inhibit the development of long-term competitiveness and sustainable development, but also may promote the formation of asset price bubbles, cause false prosperity of the economy, further accumulate systemic financial risks, and even trigger a crisis in the entire financial system. Facing the severe situation of “shift from real to frictitious”, General Secretary Xi emphasized in the report of the 20th National Congress of the Communist Party of China that we must focus on the real economy in developing the economy, and made detailed arrangements around the development of the real economy. The first meeting of the Financial and Economic Commission of the 20th Central Committee also clearly stated that the construction of a modern industrial system must adhere to prioritizing the real economy and prevent the shift from the real economy to the virtual economy. Therefore, at the key node of China's economic structural adjustment, transformation and upgrading, curbing corporate financialization and preventing “shift from real to frictitious” have important theoretical and practical significance for enhancing the overall national economic strength and risk resistance capacity.

As a special form of capital that focuses on long-term value investment and possesses significant risk-sharing capabilities, the inhibitory effect of patient capital on enterprises' irrational financialization has been attracting increasing attention in both academic and policy circles. On April 30, 2024, the Political Bureau of the Communist Party of China Central Committee explicitly proposed “expanding patient capital” for the first time at its meeting. Subsequently, the government work report reviewed and deliberated at the Third Session of the 14th National People's Congress on March 5, 2025, listed “expanding patient capital and vigorously promoting the entry of medium- and long-term funds into the market” as key annual work tasks. This further highlights its governance effectiveness in guiding capital behavior and optimizing resource allocation. With its long-term orientation, patient capital can alleviate the problem of strategic investment being crowded out due to enterprises' short-term financial performance pressure and curb the short-sighted behavior of management (Hu et al. 2025). Secondly, adhering to the concept of value investment, the inherent nature of patient capital determines that it has the motivation to guide enterprises to focus on their main business operations and the cultivation of long-term core competitiveness. This helps improve enterprises' operational efficiency and intrinsic value (Qiu et al. 2024), fundamentally weakening enterprises' impulse to engage in non-productive financial investment. Therefore, this study takes Chinese A-share listed companies from 2011 to 2024 as the sample to explore the following questions: (1) Can patient capital investment significantly inhibit corporate financialization? (2) Through which mechanisms does patient capital exert an impact on corporate financialization? (3) Are there differences in this inhibitory effect among different types of enterprises?

The marginal contributions of this study are mainly reflected in the following three aspects: (1) It expands the research on the economic consequences of patient capital. Existing literature mostly explores the role of patient capital from the perspectives of corporate performance, innovation efficiency, and total factor

productivity, but pays less attention to its impact on corporate financialization behavior. Starting from the dimension of financialization, this study provides new evidence and a mechanism explanation for understanding how patient capital guides enterprises to "shift from frictitious to real". (2) It enriches the research on the influencing factors of corporate financialization. Current studies mostly analyze the drivers of corporate financialization from the perspectives of corporate governance, manager characteristics, and macro policies. This study systematically demonstrates that patient capital, as a capital form with a long-term orientation, can inhibit the allocation of financial assets through governance empowerment and resource restructuring, which deepens the understanding of the governance path of financialization. (3) It reveals the heterogeneity of the inhibitory effect of patient capital from the perspectives of corporate information transparency and corporate regional characteristics, providing a theoretical basis and policy implications for implementing classified policies and guiding patient capital to effectively serve the real economy.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Literature Review

2.1.1 Corporate financialization

Currently, research on corporate financialization mainly explores its motivations and negative impacts. First, the motivations for financialization include two aspects: precautionary savings motivation and profit-seeking motivation. The precautionary savings motivation of enterprises aims to address uncertainties in product and financial markets, potential investment opportunities, and external shocks. Enterprises strategically increase their holdings of financial assets to enhance asset liquidity-highly liquid financial assets can be quickly liquidated in emergencies, ensuring stable operations (Zhao and Su 2020). The profit-seeking motivation refers to enterprises allocating funds to high-risk, high-return financial assets in the face of high-yield financial markets, while reducing investments in the real economy to pursue higher returns (Ding et al. 2021). In addition, the trend of financialization in non-financial enterprises is accelerating, which exerts negative impacts on corporate performance, corporate innovation and R&D, and the stability of financial markets. Regarding corporate performance, the increase in financial asset investments inhibits the improvement of future core business performance (Xing et al. 2023), and this effect is more pronounced in enterprises with high financing constraints (Guo and Xu 2021). Meanwhile, research by Gong et al. (2021) shows that short-term financial assets improve corporate performance to a certain extent, while long-term financial assets have an inhibitory effect; moreover, private enterprises and manufacturing enterprises with difficulty in obtaining loans are more sensitive to the negative impacts of long-term financialization. Regarding corporate innovation, financialization weakens enterprises' motivation for R&D (Wang et al. 2017) and crowds out R&D resources, thereby reducing innovation output (Peng et al. 2022). This impact is most significant during the growth stage of enterprises and weakens as the life cycle progresses (Xiao and Lin, 2019). Regarding financial market stability, Su (2018) found that financialization exacerbates agency problems, expands corporate risks, and increases the risk of stock price crashes. Research by Deng et al. (2019) indicates that there is a "U-shaped" relationship between the level of corporate financialization and the risk of stock price crashes-moderate investment in financial assets has positive significance, while excessive investment will increase risks. Furthermore, financialization also intensifies market uncertainty, causes management to neglect core businesses, and undermines the long-term sustainable development of enterprises.

As enterprises increase their investments in the financial sector, academic research on the influencing factors of corporate financialization has continued to deepen, covering areas from the macroeconomic environment to micro-level corporate behaviors. At the macro level, factors such as regional financial reforms (Song et al. 2025) and industrial policies (Guo et al. 2022) affect corporate financialization. At the micro level, existing studies have mainly explored the impact of corporate social responsibility (Yao and Xu, 2024), digital transformation (Xu and Wang, 2022), top management characteristics (Cai et al. 2025), and ownership structure (Deng et al. 2023; Shao et al. 2023) on corporate financialization. However, few scholars have examined the impact of long-term capital-especially patient capital with strategic orientation characteristics-on corporate financialization.

2.1.2 Patient capital

Patient capital is generally defined as a form of capital characterized by a long-term investment perspective, high risk tolerance, and deep relational embeddedness. Deeg et al. (2016) proposed that patient capital can be identified from three dimensions: investment horizon, cooperative motivation, and liquidity constraints, and defined it as a type of capital that does not aim to exit and profit in the short term but rather pursues common growth with the enterprise. Typically, the expected annualized return of such capital ranges from 5% to 10%, which is significantly lower than the required rate of return for venture capital (Ivashina and Lerner, 2019). Lin et al. (2017) further put forward the concept of "relational patient capital," emphasizing that it participates in corporate governance by establishing mechanisms for strategic synergy and risk-sharing. Qiu et al. (2024) pointed out that patient capital also features clear strategic orientation, a high

degree of resource specificity, and active participation in governance.

The characteristics unique to patient capital-long-term investment preference, strategic investment, and risk-sharing-exert an impact on corporate management decisions. In terms of financial support, patient capital can provide enterprises with long-term and stable capital support, risk buffering, and resource synergy (Harrison et al. 2016; Li and Wen, 2025). At the corporate governance level, it restrains the expropriation of interests by major shareholders, improves the decision-making efficiency of the board of directors, and strengthens the innovation incentives for management (Wang and Wang, 2020). These actions effectively curb the short-sighted behaviors of management (Gui and Li, 2024) and reduce agency costs (Schnatterly, 2014; Wu et al. 2022), thereby enhancing overall governance effectiveness. Patient capital significantly boosts enterprises' willingness and ability to conduct high-risk R&D and technological innovation (Qiu et al. 2024; Jiang and Wu, 2024). By improving enterprises' internal control mechanisms, it ensures the sustainability of their value creation capabilities, enabling enterprises to quickly optimize resource allocation when responding to market fluctuations or sudden shocks. This helps maintain long-term competitive advantages (He et al. 2024; Yang and Tang, 2025) and enhance total factor productivity (Qiu et al. 2024). In addition, some studies have shown that patient capital may lead to self-serving behaviors of management, exerting potential negative impacts on the long-term performance of companies (Deeg et al. 2016; Deeg et al. 2018). Therefore, it is worth exploring and providing evidence about how patient capital will affect corporate financialization.

2.2. Hypothesis Development

From the perspective of macro-financial stability, the trend of corporate financialization often triggers a series of chain reactions, including fueling the formation of asset bubbles, increasing the risk of corporate profit manipulation, and spurring shadow banking activities. These factors act together, ultimately leading to the gradual accumulation of systemic risks. On the other hand, from the perspective of corporate long-term value creation, the tendency toward financialization will inevitably crowd out valuable resources that should otherwise be allocated to physical investment and innovation. This, in turn, weakens enterprises' competitiveness in their core business areas and undermines their long-term stable development (Du et al. 2017). Against this backdrop, as a form of capital adhering to the concept of long-term value-oriented investment, patient capital's core goals are highly aligned with the strategic vision of corporate sustainable development, giving it the motivation to curb excessive corporate financialization. Furthermore, with its distinctive characteristics-such as a unique long-term orientation, strong risk tolerance, and strategic investment perspective (Hu et al. 2025)-patient capital is not only capable of effectively guiding and supervising corporate governance but also actively promoting enterprises to shift from the virtual economy back to the real economy, thereby achieving a positive transformation of "shifting from frictitious to real".

Based on the Resource Dependence Theory, by injecting long-term and stable cash flow into enterprises (Yang and Tang, 2025), patient capital can significantly reduce enterprises'excessive reliance on short-term liquidity reserves, thereby releasing the precautionary reserve funds originally allocated to financial assets. At the same time, its investment characteristic of being oriented toward long-term returns tends to guide enterprises to channel more funds into real economy sectors such as R&D innovation and production capacity expansion (Wu et al. 2022) to obtain more sustainable and stable long-term value, which implicitly "crowds out" the preference for investing in financial assets. Furthermore, relying on its profound professional knowledge and abundant resource advantages, patient capital can effectively improve the internal governance structure of enterprises, form a strong restraint on the short-sighted behavior of management, and reduce the probability of mistakes in enterprises' investment decisions. Meanwhile, patient capital is also able to withstand the inevitable phased fluctuations in the process of innovation activities, share the investment risks of enterprises, and thereby reduce the cost burden caused by the failure of real economy investments. This makes enterprises more daring and willing to invest in the real economy, gradually get rid of excessive reliance on the security of financial assets, and realize a healthy and sustainable development path. Based on the Signaling Theory, the investment decision of patient capital itself sends a positive signal of development confidence to the inside of the enterprise. Its stable cash flow supply and risk-sharing capability effectively alleviate the short-term performance pressure faced by enterprise management, prompting management to pay more attention to the long-term value creation of the enterprise and give priority to investing in high-quality real economy projects. Based on the above analysis, hypothes is proposed.

H1: Patient capital can inhibit corporate financialization.

Based on the Stress Cognitive Appraisal Theory, uncertainties in the return rate of physical investment will trigger defensive responses from management. Specifically, the transformation and upgrading process of the real economy is often characterized by a long cycle and high risks, which makes management prone to overestimating the severity of threats. Driven strongly by the short-term wealth effect, this cognitive bias intensifies the internal

expected performance pressure on management, thereby weakening their enthusiasm for seeking opportunities for transformation and innovation (Wang et al. 2024). In such cases, management tends to opt for financial investment in the hope of obtaining short-term, high returns to alleviate the immediate performance pressure (Duan and Zhuang, 2021). As a form of capital with long-term orientation, strong risk tolerance, and strategic characteristics, patient capital can effectively adjust the enterprise's performance evaluation cycle through its long-term capital support, thereby alleviating the pressure on management caused by short-term performance targets. In addition, the unique risk-sharing mechanism of patient capital can significantly reduce the marginal costs of enterprises in the process of developing physical businesses, thereby enhancing management's confidence when facing uncertainties. At the same time, the existence of strategic synergy provides enterprises with a clear development direction and strategic guidance.

Therefore, with the support of patient capital, management will be able to re-examine and interpret the uncertainties in the external environment, viewing them as potential opportunities for enterprise development rather than mere threats. Based on the Resource-Based View, long-term and stable capital support not only reduces enterprises' liquidity risks but also weakens their motivation to hold financial assets as a risk buffer, enabling enterprises to continuously allocate resources to the R&D of core technologies. In addition, the injection of professional knowledge and management experience that accompanies the capital input significantly improves the quality of management decisions, optimizes the efficiency of enterprise resource allocation, and further alleviates the internal expected performance pressure borne by management. Under the synergistic effect of cognitive reconstruction and resource empowerment, there is a fundamental shift in management's way of thinking-from passive risk prevention to active value creation. This shift ultimately drives enterprises to channel more resources into physical investment areas with long-term value, thereby realizing the sustainable development of enterprises.

H2: Patient capital can inhibit corporate financialization by alleviating the internal expected performance pressure on management.

3. RESEARCH DESIGN

3.1. Data

This paper selects Chinese A-share-listed companies from 2011 to 2024 as samples, data are all from CSMAR. The sample data are screened as follows: (1) the financial industry and the real estate industry are excluded; (2) firms that have been delisted or designated as ST, PT, *ST are excluded; (3) observations with missing core variables are excluded. Finally, we obtained observations of 30,038 companies, and applied winsorization at the 1 % and 99 % levels.

3.2. Main Variables

3.2.1. Independent variable

Corporate financialization (Fin). This paper draws on the research of Peng et al. (2018) and uses both a dummy variable indicating whether financial assets are allocated and a continuous variable of the ratio of financial assets to total assets at the end of the period to measure corporate financialization. Among them, financial assets include the sum of eight categories: trading financial assets, bought-back financial assets, available-for-sale financial assets, held-to-maturity investments, loans and advances, financial derivatives, long-term equity investments, and investment real estate.

3.2.2. Dependent variable

Patient capital (Pat). This study, drawing on the research by Qiu et al. (2024), constructs an evaluation system for patient capital based on its three core characteristics: a primary focus on long-term orientation, strong risk tolerance, and possession of strategic and relational attributes. This system comprises 3 first-level indicators (long-term orientation, risk tolerance, and strategic relationality) and 7 second-level indicators. In terms of long-term orientation, the turnover rate indicator is selected as the basis for classifying investors into long-term and short-term types. The corresponding shareholding ratio is calculated, and meanwhile, the ratio of an investor's shareholding ratio to the standard deviation of their shareholding ratio over the past 3 years is computed. Regarding risk tolerance, the long-term capital gearing ratio and the enterprise's short-term financial leverage are used as indicators to measure the risk tolerance of patient capital. For strategic relationality, the capital growth retention rate reflects the long-term growth trend of an enterprise's owner's equity. It embodies the enterprise's ability to accumulate capital over the long term and its sustainable development, and can also reflect the mutual trust relationship between investors and the enterprise. Therefore, it is adopted as a second-level indicator to measure the strategic relational characteristic of patient capital. Additionally, considering that an enterprise's emphasis on long-term strategies can attract long-term investors, the degree of corporate short-termism is incorporated as a consideration factor. After the indicators are constructed, data standardization is conducted, and the entropy weight method is applied to determine the weight of each indicator. Finally, the data on corporate patient capital is obtained.

3.2.3. Mediating variables

Internal expected performance pressure (IPP). Internal expected performance pressure stems from the gap between the expected performance set internally by an enterprise and the actual achieved performance (Wang et al. 2021). Its calculation

formula is as follows:

$$IPP_{it} = | I_1 * (\frac{P_{it} - A_{it}}{A_{it}}) | \quad (1)$$

In the formula, IPP_{it} represents an enterprise's internal performance pressure; Pi,t denotes the enterprise's actual performance, measured by Return on Assets (ROA); Ai,t stands for the enterprise's internal expected performance, which is calculated through a linear combination of the enterprise's historical performance and the average performance of its industry. The calculation formula for the enterprise's internal expected performance is as follows:$A_{i,t}=a_1SA_{i,t}+(1-a_1)HA_{i,t-1}$. In the formula, $SA_{i,t}$ represents the industry-average performance, measured by the average return on assets (ROA) of the industry where company i operates in year t; $HA_{i,t-1}$ denotes the historical performance of company i, measured by the ROA of company i in year t-1; a_1 is the weight. Drawing on the research by Serhan et al. (2021), the industry-average performance accounts for 70% of the expected performance, while the enterprise's historical performance accounts for 30%-thus, a_1 is assigned a value of 0.7.

If $P_{i,t} - A_{i,t} < 0$, the enterprise fails to meet its internal expected performance, and the management faces internal performance pressure: the larger the value of $IPP_{i,t}$, the greater the pressure, and I_1 is assigned a value of 1. If $P_{i,t} - A_{i,t} > 0$, the enterprise exceeds its internal expected performance, and the management faces no internal performance pressure, I_1 is assigned a value of 0.

3.2.4. Control variable

This paper draws on the relevant studies on corporate financialization (Xu and Man, 2023), selecting the following firm-level control Variables: Firm Size (size), Debt to Asset Ratio (Lev), Profitability (ROA), Enterprise growth (growth), Capital expenditure (Tangible), Largest Shareholder Ownership Ratio (Top1), Duality of Roles (Dual), Management shareholding ratio (Mshare), and Independent Director Ratio (IDRatio). Industry (Ind) and year (Year) effects are also controlled. Variables' definitions are presented in Table 1.

Table 1 Variable Definitions

Types	Var	Abbreviations	Definitions
Dependent Variable	Corporate financialization	Fin1	whether financial assets are allocated, 0 or 1
		Fin	financial assets/total assets
Independent Variable	Patient capital	Pat	drawing on the research by Qiu et al. (2024), constructs an evaluation system for patient capital
Control Variable	Firm Size	Size	Ln (total assets +1)
	Debt to Asset Ratio	Lev	Total liabilities / Total assets
	Profitability	ROA	Net profit / Total equity
	Enterprise growth	growth	(Revenue growth amount / Total revenue of the previous year) × 100%
	Capital expenditure	Tangible	Net fixed assets / Total assets
	Largest Shareholder Ownership Ratio	Top1	Number of shares held by the largest shareholder / Total shares
	Management shareholding ratio	Mshare	Number of shares held by management ÷ Total share capital of the enterprise × 100%
	Independent Director Ratio	Indep	Number of independent directors / Total number of directors

3.3 Econometric Models

To test the outcomes of Patient capital on corporate financialization, we construct the following model:

$$Fin_{it} = \gamma_0 + \gamma_1 Pat_{it} + \sum Controls_{it} + \sum Year + \sum Industry + \varepsilon_{it} \quad (2)$$

4. EMPIRICAL RESULTS

4.1 Descriptive Statistics

Table 2 presents the descriptive statistics of the sample, revealing that the mean value of Patient capital (Pat) is 0.048. The mean value of Corporate financialization (Fin) is 0.07, with a standard deviation of 0.097, indicating that there is a significant difference in the level of financialization among different enterprises. Regarding control variables, the average Firm Size (size) is 22.36, and Debt to Asset Ratio (Lev) is 0.449, both reflecting the basic characteristics of the sample companies.

Table 2 Summary Statistics

Variable	N	Mean	SD	p50	Min	Max
Fin1	30038	0.916	0.277	1	0	1
Fin	30038	0.070	0.097	0.033	0	0.537
Pat1	30038	0.048	0.054	0.030	0.001	0.290
size	30038	22.36	1.249	22.19	19.27	26.12
ROA	30038	0.032	0.065	0.033	-0.225	0.234
Lev	30038	0.449	0.191	0.446	0.051	0.883
growth	30038	0.144	0.366	0.087	-0.536	2.058
Tangible	30038	0.223	0.156	0.193	0.003	0.677
Dual	30038	0.283	0.450	0	0	1
Top1	30038	32.63	14.58	30.13	8.371	74.00
IDRatio	30038	37.62	5.347	36.36	33.33	57.14

Mshare	30038	12.31	18.08	0.717	0	69.15

On the whole, the mean value, standard deviation and value range of each variable are reasonable, and the distribution of sample data meets the requirements of research, which provides data support for the subsequent regression analysis.

4.2.Baseline Findings

Table 3 reports the regression results of the impact of patient capital on corporate financialization. Columns (1) and (2) show that when using the dummy variable Fin1 as the indicator for financialization, the estimated coefficients of Pat are significantly negative at the 1% level whether control variables are included or not, indicating that it can reduce corporate financialization. The results in Columns (3) and (4) show that when using the continuous variable Fin as the indicator for financialization, the estimated coefficients of Pat are significantly negative at the 1% level whether control variables are added or not, again indicating that patient capital can reduce corporate financialization. Hypothesis 1 is verified.

Table 3 Main Effects Regression

	(1)	(2)	(3)	(4)
VARIABLES	Fin1	Fin1	Fin	Fin
Pat1	-0.1241***	-0.3012***	-0.0642***	-0.1177***
	(-3.20)	(-7.25)	(-5.33)	(-8.67)
size		0.0459***		0.0064***
		(29.11)		(11.24)
ROA		0.0173		-0.0384***
		(0.58)		(-3.56)
Lev		-0.0038		-0.1011***
		(-0.34)		(-25.38)
growth		-0.0238***		-0.0201***
		(-4.88)		(-12.68)
Tangible		-0.1669***		-0.1517***
		(-13.28)		(-38.53)
Dual		-0.0067*		-0.0022*
		(-1.75)		(-1.86)
Top1		-0.0006***		-0.0000
		(-5.47)		(-0.04)
IDRatio		-0.0004		0.0000
		(-1.38)		(0.48)
Mshare		-0.0010***		-0.0006***
		(-8.11)		(-17.44)
Constant	0.8880***	0.0000	0.0554***	0.0205
	(54.89)	(0.00)	(12.16)	(1.62)
Observations	30,038	30,038	30,038	30,038
R-squared	0.025	0.074	0.068	0.152
Ind FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
r2_a	0.0241	0.0729	0.0665	0.151
F	33.39	46.99	41.19	79.31

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

4.3 Robustness and Endogeneity Analysis

4.3.1 The results of Endogeneity analysis

1. IV test

To address the endogeneity issue, this paper employs the instrumental variable (IV) method for testing. Drawing on the research of Qiu et al. (2024) and Yang et al. (2025), “one-period lagged patient capital” and “equity concentration” are selected as instrumental variables for patient capital. First, patient capital are associated with the proportion of shares held by the top five shareholders and the patient capital shareholdings in the previous year, satisfying the relevance requirement of instrumental variables. Second, the patient capital in the previous year and the level of shareholdings by the top five shareholders are less likely to affect the level of corporate financialization, thus meeting the exogeneity requirement of instrumental variables.

The results of the IV estimation are presented in Table 3. The first-stage regression results in columns (1) show that the regression coefficients of the instrumental variables are significantly positive, indicating that they have a positive impact on patient capital. The Kleibergen-Paap rk Wald F statistic is significant at the 1% level, rejecting the under-identification of instrumental variables. In addition, the Cragg-Donald Wald F statistic is greater than the critical value, excluding the problem of weak instrumental variables. The second-stage regression results in columns (2) show that the regression coefficient of patient capital is significantly negative at the 1% level, indicating that patient capital can inhibit corporate financialization, which is consistent with the benchmark regression results.

2. Propensity Score Matching(PSM)

To address the sample selection bias, this study employs the Propensity Score Matching (PSM) method for testing. First, a dummy variable is constructed based on the median of patient capital: firms with patient capital above the median are assigned a value of 1, while those below are assigned 0. Second, the dummy variable is set as the treatment variable, control variables as covariates, and the corporate financialization dummy as the outcome variable for 1:1 nearest neighbor matching. Finally, the matched sample is used to perform regression according to Model (1). The results in Column (3)、(4) of Table 4 show that the regression coefficient of patient capital is -0.4158、-0.1266, significantly positive at the 1% level, confirming the robustness of the research conclusions.

Table 4 Endogeneity Analysis

	(1)	(2)	(3)	(4)
variables	Pat	Fin	Fin1	Fin
Top5	0.0007***			
	(22.66)			
lPat	0.3783***			
	(19.13)			
Pat		-0.2608***	-0.4158***	-0.1266***
		(-9.77)	(-6.40)	(-6.26)
Controls	YES	YES	YES	YES
Observations	25,041	25,041	11,697	11,697
R-squared	0.674	0.153	0.073	0.162
Ind FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
r2_a	0.674	0.151	0.0694	0.159

F	596.5	69.44	18.47	34.02

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3.2 The results of Robustness test

4.3.2.1 Alternative measure of core var

Drawing on the research findings of Wu et al. (2022)、Li and Wen (2025), this study uses the stability of institutional investors' shareholdings as a proxy variable for patient capital, and identifies their long-term investment tendency inversely through transaction frequency. Specifically, first, based on the dynamic changes in institutional investors' position data, the average turnover rate of their portfolios over four semi-annual windows is calculated; second, institutional investors are sorted in ascending order of average turnover rate and divided into high, medium, and low groups, with the group having the lowest turnover rate defined as long-term oriented investors; finally, the shareholding ratio of long-term oriented investors in the target enterprise (Inst_long) is calculated to reflect the level of patient capital of the enterprise. The results are shown in Table 5 and reconfirmed the previous hypotheses.

Table 5. Alternative Measure of Core Var

	(1)	(2)
VARIABLES	Fin1	Fin
Inst_long	-0.0523***	-0.0252***
	(-7.38)	(-11.22)
Controls	YES	YES
Observations	30,038	30,038
R-squared	0.074	0.154
Ind FE	YES	YES
Year FE	YES	YES
r2_a	0.0732	0.152
F	47.25	80.83

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.3.2.2 Other robustness tests.

1. Using clustering robust standard error at the firm level; 2. Lagging independent variables by one period; 3. Excluding sample data from 2020 to 2022 to exclude the impact of the pandemic. The results are shown in Table 6, and the regression results remain consistent.

Table 6. Other Robustness Tests

	Clustering		Lagging		Excluding sample	
VARIABLES	Fin1	Fin	Fin1	Fin	Fin1	Fin
Pat	-0.3012***	-0.1177***	-0.2523***	-0.1145***	-0.3293***	-0.1240***
	(-5.44)	(-5.71)	(-5.83)	(-7.97)	(-7.50)	(-8.77)
Controls	YES	YES	YES	YES	YES	YES
Observations	30,038	30,038	23,918	23,918	22,345	22,345
R-squared	0.074	0.152	0.064	0.158	0.083	0.154
Ind FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
r2_a	0.0729	0.151	0.0620	0.156	0.0814	0.152
F	17.73	18.76	32.88	65.59	43.49	61.85

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

5. MECHANISM TEST

5.1. Mediating Mechanism Test

Patient capital can affect corporate financialization by reducing internal expected performance pressure. Therefore, drawing on the research of Jiang (2022), a three-step method is adopted for testing, and the models are as follows:

$$Med_{it} = \gamma_0 + \gamma_1 Pat_{it} + \sum Controls_{it} + \sum Year + \sum Industry + \varepsilon_{it}$$

$$Fin_1 / Fin_{it} = \gamma_0 + \gamma_1 Med_{it} + \gamma_2 Pat_{it} + \sum Controls_{it} + \sum Year + \sum Industry + \varepsilon_{it} \quad (3)$$

Med represents the internal expected performance pressure of the enterprise, and the remaining variables are the same as those in Model 2).

Columns (1) and (2) of Table 7 show that patient capital can reduce the internal expected performance pressure of enterprises, thereby inhibiting corporate financialization. Specifically, the data in Column (1) indicate that after introducing patient capital, the internal expected performance pressure of enterprises significantly decreases. The alleviation of this pressure makes enterprises no longer eager to use financialization means to rapidly improve performance, but pay more attention to long-term development and stability, reducing the allocation of corporate financial assets. Hypothesis H2 is verified.

5.2. Moderating Effect Test

Top Management Team Stability refers to the state where the members of an enterprise's executive team and its overall size remain relatively stable within a certain period, mainly reflected in the continuity of the team composition and the small fluctuation range of the team size (Yan and Zhang 2025). A stable executive team can effectively implement long-term strategies that align with patient capital. On the one hand, it ensures the consistency and coherence of management decisions, enabling enterprises to withstand the interference of short-term market fluctuations (Yan and Zhang 2025), and avoid

deviating from their main business in pursuit of short-term arbitrage opportunities in financial markets. On the other hand, a stable management team is more inclined to invest in physical assets and R&D innovations with long cycles and high specificity, which is highly consistent with the characteristics of patient capital supporting physical investment and pursuing long-term returns. Therefore, when the executive team is highly stable, patient capital can more effectively suppress the financialization tendency of enterprises, guide capital to flow into productive activities, and thus strengthen its governance effect of "de-financialization".

This paper refers to the approaches of Liu et al. (2022), and constructs the following model for measurement through the changes in the total number of executives and specific members.

$$IS_{t-1,t} = \frac{M_{t-1} - (S_{t-1} / S_t)}{M_{t-1}} * \frac{M_t}{M_{t-1} + M_t} + \frac{M_t - (S_t / S_{t-1})}{M_t} * \frac{M_{t-1}}{M_{t-1} + M_t} \quad (4)$$

In the formula, $SI_{t-1,t}$ represents the stability of the executive team in year t; M_{t-1}、Mt respectively represent the number of executives in the company's executive team at the end of year t-1 and the end of year t; (S_{t-1}/S_t) represents the number of executives who were in office at the end of year t-1 but not in office at the end of year t; (S_t/S_{t-1}) represents the number of executives who were not in office at the end of year t-1 but were in office at the end of year t. The value range of SI is 0-1, and the larger the SI, the more stable the executive team.

This paper constructs the following model to test the moderating effect of executive team stability:

$$Fin_{it} = \gamma_0 + \gamma_1 Pat_{it} * SI_{it} + \gamma_2 Pat_{it} + \gamma_3 SI_{it} + \sum Controls_{it} + \sum Year + \sum Industry + \varepsilon_{it} \quad (5)$$

In the formula, SI represents top management team stability, and the remaining variables are the same as those in Model (2).

Column (5)、(6) of Table 7 presents the regression results of the moderating effect of executive team stability. The interaction term Pat*SI is significant at the 1% level, indicating that an increase in the stability of the enterprise's executive team enhances the inhibitory effect of patient capital on the enterprise's financialization behavior.

Table 7. Mechanism Test

	(1)	(2)	(3)	(5)	(6)
VARIABLES	IPP	Fin	Fin1	Fin	Fin1
IPP		0.0015***	0.0002		
		(3.42)	(0.20)		
Pat	-0.6980***	-0.1167***	-0.3011***	-0.3198***	-0.1238***
	(-3.82)	(-8.59)	(-7.25)	(-7.53)	(-9.02)
SI				0.0243**	-0.0024
				(2.49)	(-0.75)
Pat*SI				-0.3103**	-0.1017**
				(-2.03)	(-2.03)
Controls	YES	YES	YES	YES	YES
Observations	30,038	30,038	30,038	28,644	28,644
R-squared	0.184	0.152	0.074	0.076	0.153
Ind FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
F	80.10	77.54	45.95	0.0745	0.152
r2_a	0.183	0.151	0.0729	44.77	73.83

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

6. HETEROGENEOUS EFFECTS

6.1 Corporate regional Characteristics

Compared with the western region, the eastern and central regions have a higher level of economic development, a complete financial system, easier access to financial assets for enterprises, and greater convenience for financialization driven by profit-seeking motives. Therefore, patient capital has a significant inhibitory effect on the financialization of enterprises in the eastern and central regions. Based on this, this paper divides the enterprise samples in 31 regions into central-eastern and western regions (Zhao et al. 2025), to test whether there is regional heterogeneity in the impact of patient capital on the level of corporate financialization. A regional dummy variable area is constructed: if an enterprise is located in the eastern or central region, area is assigned a value of 1; if it is in the western region, area is assigned a value of 0.

6.2. Enterprise Information Transparency

High information transparency can alleviate information asymmetry between enterprises and

external investors, providing a decision-making basis for patient capital. Patient capital has a long-term orientation, and its investment decisions depend on judgments about the enterprise's true value and innovation potential (Wu et al. 2022). Sufficient information disclosure can reduce the information collection and verification costs for patient capital, helping it identify enterprise value, supervise capital flows, and prevent resources from deviating from the main business. Meanwhile, a high-transparency environment can strengthen the governance effect of patient capital, suppress short-term speculation by management (Feng et al. 2025), and guide enterprises to focus on long-term value creation and physical investment. Referencing the research of Feng et al. (2025), this paper measures enterprise information transparency by using the absolute value cumulative sum of discretionary accruals (Opaque) over the recent three years. The higher the Opaque value, the poorer the information transparency of the enterprise. The results of the grouping test show that the inhibitory effect of patient capital on corporate financialization is more significant in enterprises in central and eastern regions and those with high information transparency.

Table 8 Heterogeneity Analysis

	(1)	(2)	(1)	(2)
VARIABLES	Area=0	Area=1	Opaque=0	Opaque=1
Pat	-0.0906**	-0.1206***	-0.1316***	-0.0480*
	(-2.43)	(-8.24)	(-8.21)	(-1.93)
Controls	YES	YES	YES	YES
Observations	3,871	26,167	17,242	12,796
R-squared	0.143	0.155	0.138	0.182
Ind FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
r2_a	0.134	0.154	0.136	0.179
F	11.26	71.99	42.80	40.66
Diff	0.073**		-0.075***	

Robust t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

7. CONCLUSION AND POLICY IMPLICATIONS

This study selects Chinese A-share listed companies from 2011 to 2024 as the research objects and systematically examines the impact of patient capital on corporate financialization. The research results show that the introduction of patient capital can significantly inhibit corporate financialization, and this conclusion remains valid after multiple robustness tests, including instrumental variable (IV) method, propensity score matching (PSM), and changing the measurement indicators of the explanatory variable. Further mechanism tests indicate that patient capital inhibits corporate financialization by alleviating internal expected performance pressure, and Top management team stability strengthens this inhibitory effect. Heterogeneity analysis reveals that the governance effect of patient capital is more prominent in enterprises with high information transparency and those located in the central and eastern regions of China. Based on the above research conclusions, this study puts forward the following policy recommendations: First, the government should actively adopt various measures, such as establishing special guidance funds, providing tax incentive policies, and implementing risk compensation mechanisms, to strongly encourage long-term capital to act as patient capital and invest in real economy enterprises. Priority should be given to supporting enterprises engaged in technological innovation and those in the early stage of development, providing them with stable capital support to facilitate their growth. Second, improve the multi-level and all-round financial market system, promote enhanced collaboration among various financial institutions, and actively innovate financial products and services. These efforts aim to effectively alleviate the financing constraints of small and medium-sized enterprises and reduce the passive motivation of these enterprises to engage in financialization due to financing difficulties. In addition, optimize the external environment for corporate governance, actively guide institutional investors to participate more proactively in corporate governance, promote enterprises to establish and improve long-term performance evaluation systems, and on this basis, strengthen the information disclosure system to enhance the transparency of corporate operations. This will further strengthen the governance effect of patient capital in corporate management and promote the long-term stable development of enterprises.

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