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CONTENTS

A Practical Exploration of the Production-oriented Approach in Junior High School English Writing Teaching

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Abstract: Junior high school English writing teaching has long been constrained by traditional models, which overemphasize teacher-centered instruction and exam-oriented training, resulting in students' weak autonomous thinking ability and practical language application ability. As an emerging teaching theory, the Production-Oriented Approach (POA) centers on "output-driven, input-enabled, and evaluation-integrated", emphasizing the improvement of students' comprehensive language application ability through real writing tasks. This paper first This paper first elaborates on the theoretical system of the Production-Oriented Approach, including teaching principles, teaching hypotheses, and teaching procedures; secondly, it analyzes the role of this theory in stimulating students' writing interest, improving practical language application ability, cultivating creativity and critical thinking, and promoting the development of comprehensive abilities; further, combined with the case of the People's Education Press textbook for junior high school English, it designs a writing teaching practice plan based on the Production-Oriented Approach; finally, it provides theoretical reference and practical paths for optimizing junior high school English writing teaching.
Keywords: Production-oriented Approach; Junior High School English Writing; Teaching Practice; Writing Ability

1. INTRODUCTION

The traditional English writing teaching model, which focuses on grammar rules and vocabulary indoctrination, separates language knowledge from practical application. As a result, although students master basic language rules, they are unable to complete writing tasks in real situations. Moreover, due to the over-emphasis on result evaluation, students' writing confidence and interest are weakened. In this context, the Production-Oriented Approach (POA), a foreign language teaching theory proposed by Professor Wen Qiufang, with "integration of learning and using" as its core, takes language output as the learning goal and motivation through the closed-loop teaching process of "motivating-enabling-assessing", effectively connecting input and output, and providing a new idea for solving the predicament of traditional teaching.

This study focuses on the application of the Production-Oriented Approach in junior high school English writing teaching, which has two significances: at the theoretical level, by systematically sorting out the teaching principles (learning-centered, integration of learning and using, cultural exchange, key competencies), teaching hypotheses (output-driven, input-enabled, selective learning, assessment for learning) and teaching procedures of POA, it enriches the theoretical support for junior high school English writing teaching; at the practical level, combined with the writing task of "school trip diary" in the People's Education Press textbook, it designs specific teaching plans to verify the effectiveness of POA in stimulating students' writing interest, improving language application ability and cultivating comprehensive literacy (such as critical thinking and cross-cultural awareness).

The research aims to solve two core problems: one is how to design English writing teaching procedures in line with the cognitive characteristics of junior high school students based on POA theory; the other is how to improve junior high school students' writing ability and learning motivation through POA teaching practice. Through the combination of theoretical analysis and teaching cases, it provides an operable practical path for the reform of junior high school English writing teaching, helping students master writing skills while achieving the coordinated development of language ability and key competencies.

2. OVERVIEW OF THE PRODUCTION-ORIENTED APPROACH

2.1 Definition of POA

POA is developed from the output-driven hypothesis [1]. The primary objective of this theory is to promote the reform of the English language curriculum, aiming to address the drawbacks of separating learning from practice and to improve the inefficiency of foreign language teaching in Chinese universities[2]. From the early Output-driven hypothesis to the Output-driven, Input-enabled hypothesis, the POA system was formally named as production-oriented approach in October 2014. Two points need to be emphasized in this theory. First, this approach is mainly applicable to senior and advanced English learners. If the European Common Reference

Framework is used to measure, students' English level must achieve to A2 or higher. In order to adapt POA to junior high school English teaching, the method of combining Reading-to-write is adopted. Secondly, POA involves more than just speaking and writing; it also includes interpreting and translating. This approach emphasizes both the process and the results of output.

As mentioned, the theoretical system of POA is composed of three parts: teaching principles, teaching hypotheses, and teaching processes. Their interrelationships can be summarized as follows: the teaching principle serves as the guiding ideology for both the teaching hypotheses and processes; the teaching hypotheses provide the theoretical foundation for the teaching process; and the teaching process is the realization of the hypotheses and principles. Therefore, POA is not merely a teaching method but a comprehensive and precise theoretical system for English language instruction.

2.2 Theoretical System of POA

POA is a new theory of foreign language classroom teaching put forward by Professor Wen Qiufang. After nearly eight years of development, a complete theoretical system was formed in 2015. This system comprises three core components: teaching principles, teaching hypotheses, and teaching processes. To be specific, learning-centered principle, learning-using integrated principle and whole-person education principle are included in teaching principles. Teaching hypothesis includes output-driven hypothesis, input-enable hypothesis and selective learning hypothesis. Teaching process covers motivating stage, enabling stage and assessing stage, and the process is carried out through the mediation of teachers. Figure 1 shows the theoretical system of POA.

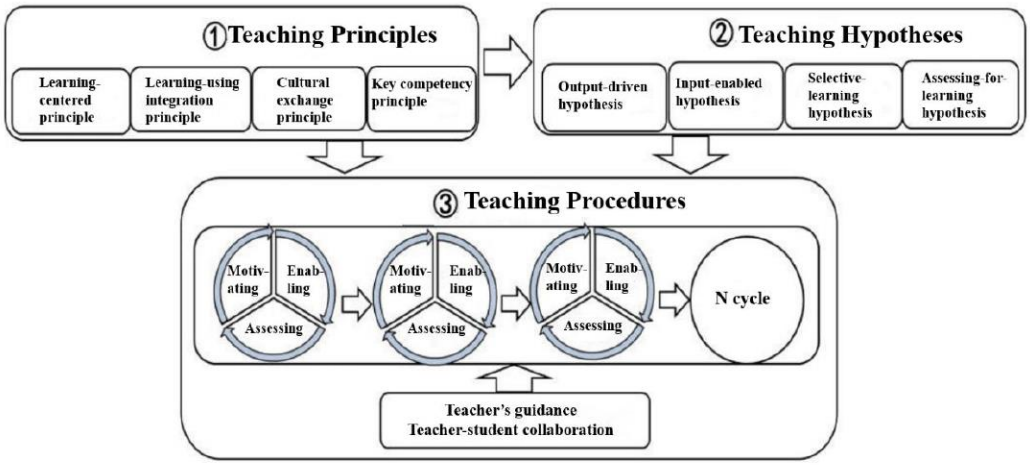

Figure 1 Theoretical System of POA

2.3 Teaching Principles

As has been discussed above, the teaching principles are the guidelines of POA theory. The principles focus on students' real learning and attract students' attentions to the practices of their learning [3]. In the principles,it is advocated that the education that students received should train them to be well-developed and have the overall abilities that enable them to adapt to the challenges of a competitive society.

The POA teaching principles include four main ideas: "the learning-centered principle", "the learning-using integration principle", "the cultural exchange principle", and "the key competency principle"[4]. These principles provide the direction for implementing teaching hypotheses and procedures.

“The learning-centered principle" emphasizes that all teaching activities are oriented towards "learning", posing a challenge to the current "Student-centered" pedagogy[4]. Historically, teaching revolves around teachers and students, leading to the formation of "Teacher-centered" and "Student-centered" paradigms. The "Teacher-centered" approach assigns teachers the responsibility of decision-making and execution, placing them in a dominant role, while students act as collaborators in teaching activities. This educational philosophy reveals significant drawbacks: it overemphasizes the role of teachers in teaching activities, stifling students' creativity and interest in learning, and resulting in issues such as an excessive focus on teaching rather than learning[5]. In contrast, the "Student-centered" approach advocates that students should occupy the primary and dominant position in teaching activities, questioning the "Teacher-centered" approach but excessively weakening the role of teachers, thereby compromising learners' learning efficiency. Addressing the shortcomings of these two pedagogies, Wen Qiufang proposed the "the learning-centered principle" which emphasizes both the leading role of teachers and the subjective role of students, ensuring that all teaching activities must serve effective learning to facilitate the achievement of teaching objectives.

"The learning-using integration principle" emphasizes the integration of input and output in classroom

teaching. Within this framework, "using" serves as the purpose of "learning," embodied through the form of output goals, which means students should use English to complete tasks; "learning" is the means to achieve these output goals, determining what content needs to be learned to fulfill the output objectives[6]. This teaching principle is proposed to address the prevalent issue of "separation between learning and using" in English teaching in China. It advocates that students "learn from application" and "using in learning" closely integrating input knowledge with output application. In the teaching of the POA, teachers establish several sub-goals to achieve seamless integration of input and output, ultimately reaching the overall goal of classroom teaching.

“The cultural exchange principle" is oriented towards teaching content, incorporating both the learners' native culture and the target language culture to foster learners' intercultural communicative competence. This teaching principle believes that different civilizations should engage in dialogue, respect, understand, and learn from each other[7]. For second language learners, they must learn to manage the relationship between their native culture and the target language culture during the learning process. American linguist Edward Sapir (1921) stated in his book, *An Introduction to the Study of Speech,* that "language does not exist apart from culture". Language is the carrier of culture and a manifestation of culture. People can only grasp the cultural knowledge of human society through language. Learning a national language is learning its culture [8]. Therefore, in the process of language teaching, teachers should consider the different cultural backgrounds of students and adopt appropriate teaching strategies to enhance learners' understanding of the target language culture and facilitate linguistic exchanges across cultures.

"The key competency principle" is a newly introduced teaching philosophy based on teaching objectives to develop students' key competencies. The POA in foreign language education proposes six key competencies: linguistic competence, learning ability, critical thinking, cultural competence, innovative ability, and cooperative ability. Linguistic competence encompasses not only the ability to understand and express through listening, speaking, reading, writing, and viewing but also the formation of language awareness and intuition through language learning and use, aspects that develop in social contexts. Learning ability refers to students' awareness and ability to actively choose and apply appropriate English learning strategies and acquire knowledge through multiple channels to improve English learning efficiency. Critical thinking refers to the abilities and levels demonstrated in logic, criticism, and innovation. Cultural competence involves the ability to demonstrate cross-cultural awareness, attitudes, and behaviors towards different cultural expressions in a globalized context. Innovative ability refers to students' ability to boldly attempt and create new ideas. Cooperative ability refers to students' ability to learn to cooperate with others in society and handle the relationship between individuals and collectives. Among these six key competencies, linguistic competence is the foundation for the development of the other five, which interact and are interconnected. In the process of language teaching, teachers should appropriately integrate the cultivation of multiple competencies into instructional design, enabling students to develop their key competencies while learning the language.

2.4 Teaching Hypotheses

The teaching hypotheses proposed in POA include "the output-driven hypothesis", "the input-enabled hypothesis", "the selective-learning hypothesis", and "the assessing for learning hypothesis". These hypotheses provide the theoretical basis for the teaching procedures and are guided by teaching principles.

"The output-driven hypothesis" is in line with Swain's Output Hypothesis, which posits that output is more beneficial than input for second language acquisition. The hypothesis suggests that output not only motivates learners but also serves as the goal of language acquisition. In practice, teachers should first encourage students to produce output, which will highlight their language deficiencies, thereby motivating them to seek the necessary input. This output-input-output sequence enhances teaching efficiency and improves language output.

"The input-enabled hypothesis" views input as serving the purpose of better output. Based on learners' production goals, they selectively learn from the relevant input materials provided by teachers after attempting to produce output, thereby enabling the completion of production tasks and achieving better learning outcomes. In this process, input and output are closely linked, which not only allows students to recall existing knowledge but also facilitates the learning and application of new knowledge.

"The selective-learning hypothesis" (Wen, 2015) refers to learners selecting useful parts of knowledge from the input materials provided by teachers for in-depth processing, practice, and memorization based on the needs of production tasks. As mentioned in "*Cognitive Psychology"* by Solso, "We are highly selective in the types and amounts of information we attend to at any one time. If too many sensory cues are present simultaneously, we feel overloaded." Therefore, the instructional materials provided by teachers should be based on production goals.

"The assessing for learning hypothesis" is proposed to address the issue of the separation between learning and assessment. It views assessment as another crucial aspect of learning. Therefore, teachers need to reassess the role of assessment in instruction. Under the guidance of the POA, teachers integrate

assessment with themselves and students, thereby demonstrating the indispensability of assessment in instruction while achieving the purpose of reinforcing and enhancing students' learning.

2.5 Teaching Procedures

The teaching procedures of POA consists of several cycles comprising three key stages: "motivating", "enabling", and "assessing". It is a teacher-led instructional process that emphasizes the collaborative construction between teachers and students, providing a theoretical foundation and guidance for teaching practice.

The motivating stage, as the first part of the teaching procedures, unfolds in three steps: Firstly, teachers create authentic communicative scenarios that may occur in students' future lives, where students engage in communicative activities requiring language knowledge within their "zone of proximal development", meaning the required language level is slightly above their current proficiency. Secondly, students attempt to produce output to complete communicative tasks, during which they become aware of their linguistic inadequacies and are unable to successfully complete the tasks, thereby generating a desire to learn. Finally, teachers clarify the instructional objectives and production tasks for students. The instructional objectives are mainly divided into two types: communicative objectives, which refer to the completion of communicative tasks and effective communication; and linguistic objectives, which specify the vocabulary, phrases, or grammatical knowledge to be mastered. Production tasks can be either in-class, where production practice and input learning are synchronized, or post-class, where teachers assign production practice for students to complete outside of class. In this stage, teachers design corresponding production tasks for students to complete based on different types of instructional objectives.

The enabling stage is the core of the POA teaching procedures, comprising three steps: teachers describe the production tasks; students selectively learn materials with guidance and checking from teachers; and students practice producing output with further guidance and checking from teachers. Enabling primarily involves input materials in terms of content, language, and discourse structure. Firstly, in terms of content, the description of production tasks requires input materials for assistance to clarify them to students. Secondly, enabling involves linguistic expression forms, including words, phrases, and sentence patterns. Finally, it addresses discourse structure, though the discourse structure learned from input materials can only serve as an auxiliary in initial production, with true creativity encouraged in students' production. During these three aspects of enabling, teachers should guide students to selectively learn different task contents based on the varying focus and difficulties of learning tasks at each stage. At the same time, teachers should promptly check the results of students' selective learning to ensure learning effectiveness. According to the instructional requirements of the POA, students' production practice should progress step by step under teachers' guidance. To verify whether students can complete production tasks, teachers should evaluate immediately after students' practice.

The assessing stage is an indispensable part of the POA teaching procedures, with teaching evaluation divided into immediate evaluation and delayed evaluation. Immediate evaluation involves teachers assessing students' production practice and selective learning in class, allowing teachers to control the instructional pace and understand students' mastery of knowledge. Delayed evaluation occurs after students submit their writing exercises for evaluation by teachers. Given the heavy workload of evaluation faced by teachers, "teacher-student collaborative evaluation" is proposed as a supplement to other evaluation methods. This evaluation mode involves pre-class, in-class, and post-class evaluation subjects, focusing on students' production quality and the completion of instructional objectives, with teachers and students collaboratively evaluating typical samples.

3. THE ROLE OF PRODUCTION-ORIENTED APPROACH IN JUNIOR HIGH SCHOOL ENGLISH WRITING TEACHING

3.1 Stimulating students' Learning Interest and Autonomy

One of the roles of the Production-Oriented Approach in junior high school English writing teaching is to stimulate students' learning interest and autonomy. By designing specific writing tasks, such as writing a travel diary or describing one's dream, students can engage in writing practice in real situations, thereby enhancing their writing motivation and participation, and improving their learning enthusiasm. When students are interested in writing tasks and feel autonomous, they are more likely to devote themselves to the writing process [2]. Such devotion helps improve the quality of students' writing and their expressive ability. Students will actively think about how to organize their ideas, select appropriate vocabulary and sentence patterns, so as to achieve better writing results.

3.2 Improving Students' Practical Language Application Ability

The application of the Production-Oriented Approach in junior high school English writing teaching aims to improve students' practical language application ability, enabling them to better cope with daily communication and academic scenarios. Firstly, in the writing process, students need to consider how to accurately express their thoughts and viewpoints, and select appropriate vocabulary and sentence structures. Through mistakes and feedback in practice, students can gradually improve their language expression

ability, and enhance the accuracy and fluency of language. In addition, students will learn to use different language resources, such as dictionaries, grammar books and the Internet, to support their writing activities, thereby expanding their vocabulary and language knowledge. Secondly, through practical language use, students transform language knowledge into practical language skills [3]. In the writing process, they not only need to pay attention to the correct use of grammar and vocabulary, but more importantly, consider the coherence of language, the adaptability to context and the accuracy of expression. Through practical practice and feedback, students can better understand and apply the characteristics and rules of the English language, and improve their writing level and language ability.

3.3 Cultivating Students' Creativity and Critical Thinking

The Production-Oriented Approach plays an important role in cultivating students' creativity and critical thinking in junior high school English writing teaching. Firstly, in the writing process, students need to think about how to organize and present their ideas. They need to consider how to describe scenes, shape characters or solve problems in a unique way. This thinking process prompts students to discover new ideas and ways of thinking, thereby cultivating their creativity and imagination. Secondly, the Production-Oriented Approach also encourages students to think critically and analyze. In writing tasks, students need to analyze the selected topics, evaluate viewpoints, and put forward their own viewpoints and supporting reasons. The cultivation of this critical thinking prompts students to think about problems from multiple perspectives and form their own independent viewpoints.

3.4 Promoting the Cultivation of Comprehensive Abilities

Writing is a comprehensive language application activity, which requires students to conduct comprehensive training in language expression, logical thinking, content organization and other aspects, and the Production-Oriented Approach helps to cultivate students' comprehensive abilities. Firstly, in the writing process, students need to carry out a lot of thinking activities, including sorting out ideas, conceiving content, analyzing problems, etc. This kind of thinking activity promotes the cultivation of students' comprehensive thinking ability. They need to consider how to express clear viewpoints in appropriate language and how to organize materials to make the content of the article coherent, which all require students to conduct overall thinking and analysis [4]. Secondly, writing requires students to conduct comprehensive training in content organization, logical reasoning and information integration. They need to clarify the relationship between the theme and sub-arguments, collect and analyze arguments, deduce and draw conclusions, etc. These activities help to cultivate students' overall thinking ability and logical thinking ability.

4. TEACHING DESIGN PRACTICE OF JUNIOR HIGH SCHOOL ENGLISH WRITING BASED ON PRODUCTION-ORIENTED APPROACH

The writing task in this paper is derived from the writing exercise part of Unit 7 "A Day to Remember" in the People's Education Press textbook for junior high school English, with the title "Write a diary about a school trip". The content of this course is closely related to students' daily study and life, and has high practical value. It aims to guide students to write a concise, coherent and well-structured diary to share their school trip experience, and appropriately incorporate sentences expressing emotions.

4.1 Motivating Stage

Situation introduction and topic presentation: Stimulate students' interest by explaining that the school will hold a writing competition of "Unforgettable School Trip". Focus on two core questions "What school trip did you have?" and "What was your most unforgettable school trip?", guide students to conduct oral output, and require the answers to cover 5 key points:

✓ When did you go on your school trip?
✓ Where did you go?
✓ What did you do there?
✓ What did you see there?
✓ How did you feel about the trip?

At the same time, introduce the practicality of the task, emphasizing that diaries are an important way to record life and express emotions. Stimulating students' learning desire: Guide students to recall their own experiences through the above questions, expose their deficiencies in vocabulary, sentence patterns or logic in oral expression (such as being unable to accurately describe activity details or emotions), make students aware of their lack of expressive ability, and thus stimulate the motivation for active learning. Clarifying teaching objectives and output tasks: Teachers explain the writing task - students need to record their own school trip experience in the form of a diary, requiring real content, sincere emotions, and compliance with the format specifications of diaries.

4.2 Enabling Stage

Selection of input materials: The reading article "A school trip to the farm" in this unit is used as the core input material for students to learn and imitate, enriching their cognition of the language expression, structure organization and content presentation of diaries.

Learning of structure, content and language: Design activities around the structure, content and language characteristics of diaries to help students master how to organize diary content, express activities and feelings in trips, and realize the integration of learning and using. Students need to apply the learned knowledge to writing, and complete personalized

school trip diaries through imitation and innovation.

Input of vocabulary and phrases: Teachers provide vocabulary and phrases related to diaries, covering five dimensions of "what was seen, what was heard, what was done, what was felt, what was learned", for example:

✓ What was seen: large tents with tomatoes and cucumbers and many other fruits and vegetables

✓ What was done: pick strawberries, cut branches and leaves, water plants, took some vegetables home

✓ What was felt: interesting, tired but pleased, happy, proud, satisfied

✓ What was learned: Farming isn't easy; every grain comes from hard work

Sentence pattern practice: Guide students to read the model text "A school trip to the farm", focus on learning and practicing sentence patterns related to diaries, especially strengthen the use of the simple past tense (such as "I picked strawberries" "We watered plants"), to ensure that the tense is consistent with the context of diaries recording "trips that happened in the past".

Content enabling: Teachers organize brainstorming activities, first provide 10 common school trip locations (such as farm, park, aquarium, zoo, museum, amusement park, factory, etc.), then divide students into groups of 4, carry out discussions around the questions "Where did you go? What did you see/hear/do? How did you feel? What did you learn?", and complete the form records to accumulate materials for writing.

Structure enabling: Teach the basic format of diaries, including:

✓ First paragraph: Explain the time and place of the trip (such as "Last Friday, our class went to Green Farm for a school trip.");

✓ Middle paragraph: Describe the activity process, what was seen and heard in detail (such as "First, we picked strawberries in the field. They were sweet and juicy.");

✓ Last paragraph: Express feelings and gains (such as "I felt tired but happy. I learned that farming needs patience.").

Practical activities: Students, in groups, try to build a diary framework based on the content of the form formed through discussion; teachers patrol and guide to help sort out the logic.

Summarizing the framework and structure output: Guide students to combine input materials and group discussion results, independently extract the writing framework, form a detailed outline, clarify the core content of each paragraph, and lay the foundation for formal writing.

4.3 Assessing Stage

The evaluation link of this teaching design adopts the delayed evaluation method, reflecting the teacher-led, student-centered and the integration of evaluation and learning.

Showing samples and conducting joint discussion: Teachers select several excellent diaries and anonymous diaries to be improved as cases, guide students to discuss in groups from three aspects: content (whether it completely covers travel details), language form (whether the tense is correct, whether vocabulary is used appropriately), and text structure (whether the format is standard, whether the logic is coherent), and analyze the advantages, problems and modification suggestions.

Teacher guidance and teacher-student joint evaluation: Representatives of each group share the discussion results. Teachers play the role of "scaffold", guide students to summarize common problems (such as misuse of past tense, general description of feelings, etc.), and jointly formulate evaluation standards and score sheets with students (such as 30% for content integrity, 30% for language accuracy, 20% for structure standardization, 20% for emotional authenticity).

Student self-evaluation and peer evaluation: Students conduct self-evaluation according to the evaluation standards, reflect on the deficiencies of the diary in content, language and structure and make preliminary revisions; After completing the revision, conduct peer evaluation, check each other and provide specific revision suggestions; Teachers select excellent revised model texts and display them in subsequent courses to provide students with reference examples for improvement[5-9].

5. CONCLUSION

This study explores the application of the Production-Oriented Approach (POA) in junior high school English writing teaching, and systematically verifies the effectiveness of this theory in optimizing junior high school English writing teaching through theoretical combing, role analysis and practical design.

From the theoretical level, the Production-Oriented Approach, with teaching principles (learning-centered, integration of learning and using, cultural exchange, key competencies), teaching hypotheses (output-driven, input-enabled, selective learning, assessment for learning) and teaching procedures as the framework, breaks the limitation of "separation of learning and using" in traditional teaching, and provides scientific theoretical support for junior high school English writing teaching. Its core value lies in taking language output as the starting point and goal of learning, driving students to actively discover their own language shortcomings through real tasks, then promoting the improvement of output quality with targeted input, and finally realizing the closed loop of learning and reflection through the evaluation link. This process not only emphasizes the guiding role of teachers, but also respects the subjectivity of students, which is in line with the cognitive law of junior high school students' language learning.

From the practical value, English writing teaching in junior high schools based on POA has shown

multi-dimensional effects: in the writing case of "school trip diary" in the People's Education Press textbook, through the design of "situation motivation - material enabling - multiple evaluation", students not only master the format specifications, language expression (such as the use of the simple past tense) and structure organization skills of diaries, but also stimulate their writing interest in real tasks and improve their ability to transform language knowledge into practical expression. At the same time, activities such as group discussions and brainstorming integrated into the teaching process have effectively cultivated students' critical thinking, creativity and cooperation ability, confirming the role of POA in promoting the development of students' key competencies.

However, this study still has certain limitations. For example, the teaching case only focuses on a single textbook unit, and its applicability needs to be further verified in more genres (such as letters, speeches); in addition, the discussion on differentiated teaching strategies for students with different English levels is insufficient. Future research can expand teaching scenarios, refine hierarchical teaching design, and conduct in-depth analysis of the sustained impact of POA on the improvement of students' writing ability through long-term tracking data.

In conclusion, the Production-Oriented Approach provides a complete path from theory to practice for junior high school English writing teaching. It is suggested that front-line teachers flexibly use the "motivating-enabling-assessing" process of POA in teaching, design real and interesting writing tasks combined with textbook content, and pay attention to the pertinence of input materials and the diversification of evaluation methods, so as to realize the coordinated development of students' writing ability and comprehensive literacy, and lay a foundation for cultivating English learners with cross-cultural communication ability and innovative thinking.

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Double Wastelands: An Analysis of the Grass Is Singing from an Ecofeminism Perspective

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Abstract: The Grass is singing was published in 1950 by Doris Lessing, who won the Nobel Prize for Literature in 2007. This novel represents not only the oppression of colored people by colonizers and women by men, as well as humanity's oppression of nature. It depicts the spiritual wasteland under colonialism and patriarchal cultural oppression, and the ecological wasteland under the rule of anthropocentrism. The novel profoundly criticizes the systematic destruction of South Africa's natural ecology by colonial economy, as well as the distortion of human nature typified by Moses and Mary under colonial hegemony and patriarchy. It reveals the internal connection between the collapse of ecological order and the demise of the subjectivity of the oppressed. By integrating colonial violence, gender oppression, and ecological crisis into a unified analytical framework, Doris Lessing demonstrates resistance to traditional binary oppositions and yearns for eliminating differences and establishing equal relationships.
Keywords: Ecofeminism; Ecological Wasteland; Spiritual Wasteland.

1. INTRODUCTION

Doris Lessing (1919-2013) was born in Persia (now Iran), and both of her parents were British. When Lessing was a child, her father led the whole family to move to Southern Rhodesia (now Zimbabwe), where they worked on a farm. Lessing's life experience in African colonies provided a unique perspective for her literary creation. The vast natural environment and acute ethnic conflicts in Africa became the main themes of her early works.

Lessing has a broad vision and profound insights. Her works extensively cover social and political hot issues such as colonialism, feminism, apartheid, and ecological environment. With the outbreak of World War II, the gradual disintegration of the colonial system and the rise of the feminist movement, Lessing not only focused on the natural ecological wasteland of the colonies in her works, but also critically interpreted the polluted spiritual ecology of humanity, especially that of the battered women. Therefore, the ecofeminist ideology reflected in her works has attracted the attention of scholars.

Ecofeminism is an interdisciplinary theory that emerged in the late 20th century, integrating feminism and ecological criticism. It focuses on the systemic oppression suffered by women and nature and their liberation. Ecofeminist scholars believe that women, nature, and all marginalized groups are all within the binary oppressive structure of patriarchy. There is the same internal logical relationship between the exploitation of nature by humans and the oppression of women by men (Wei Qingqi, 2019:148). Previous studies have mostly focused on a single dimension, such as separately exploring the impact of colonialism on racial relations or the constraints of patriarchy on women. This article will focus on Lessing's representative work *The Grass Is Singing*, attempting to analyze the three fundamental themes of race, gender, and nature in the novel.

The Grass Is Singing focuses on the analysis of white women represented by Mary and black men represented by Moses, supplemented by the analysis of marginal characters in the novel. It explores the complex interaction between women and nature in a colonial context, delves deeply into the cross-analysis of colonialism and patriarchal oppression, and interprets the relationship between humans and nature. This article tries to analyze the spiritual wasteland of the oppressed and the ecological wasteland of nature reflected in the novel from the perspective of ecofeminism.

The traditional western philosophical defines human beings as rational subjects beyond nature, while nature is belittled as an object resource that can be conquered. Under the patriarchal system, men dominated the main course of social development, excluding women from rational capabilities. Therefore, men consider themselves more rational and closer to culture. "However, women are also human beings and possess rational thinking abilities. Mary Wollstonecraft believed that the reason why women do not seem as resolute, independent and thoughtful as men lies in the fact that the prejudice of the entire society, especially men, has shaped women into a weak and dependent appearance"[1]. This social connection between women and nature, men and culture, places both women and nature in a state of oppression. Therefore, ecofeminism is committed to simultaneously resisting these two forms of oppression and dissolving the ruling logic behind them, proposing two models of "hermaphroditism" and "dialogue between the two sexes" to replace the oppressive male chauvinism[2].

It is worth noting that although some ecofeminists, especially cultural ecofeminists, place more emphasis on the physiological essence of women and advocate

the theory of female superiority, believing that women are closer to nature than men because of their physiological traits. However, the similarity in the status of women and nature is caused by the same ruling logic, so the close relationship between women and nature is constructed and imagined. Ecofeminists believe that logocentrism is the root cause of the logic of co-domination that oppresses women and nature. "Apart from being manifested as male chauvinism in feminist criticism and anthropocentrism in ecological criticism, the ruling logic of logocentrism also appears in the oppression of the other by all other centers"[2]. Ecofeminists criticize all oppressive systems and ruling logics based on logocentrism, emphasizing the need to break this value system and re-establish harmony between humans and nature, as well as between men and women.

2. THE SPIRITUAL WASTELAND UNDER DOUBLE OPPRESSION

Double oppression refers to the oppression of colonialism and patriarchal culture. In *The Grass is Singing*, the female protagonist Mary is a descendant of British immigrants born in South Africa. She spent her childhood in poverty. The backward and isolated town and her constantly quarrelling parents made her want to escape from her current life. Originally, Mary found a well-paid job after graduation and led a peaceful and comfortable single life. However, at the age of thirty, Mary, in an attempt to regain her sense of superiority over men, hastily married the small farmer Dick and began a new life with the mindset of "getting close to nature". The poor and lonely life after marriage made Mary realize that she was following in her mother's footsteps, but the intrusion of the black man Moses disrupted her numb and chaotic life. In the end, the ambiguous relationship between the two was discovered by others and turned into a conflict. So, enraged, Moses killed Mary.

2.1 Oppression by Colonialism

Vandana Shiva, a representative of ecofeminism in the Third World, pointed out that the world system of capitalist patriarchy is based on "three colonizations", namely, the colonization of women, the colonization of foreigners and their lands, and the colonization of nature. It is precisely the "The colonization of regenerative sources of the renewal of life is the ultimate ecological crisis"[3]. Mary grew up in a complex social environment. As a descendant of British immigrants born in South Africa, although she and her parents have never been to the UK, she has always believed that her homeland is England, not the place where she grew up. This reflects the scattered consciousness of South African whites who yearn for Britain and distance themselves from Africa.

Mary was in the South African colony. The cruel exploitation of the indigenous black people by the colonists was nothing new to her. The influence of the white supremacy culture made her have a strong sense of white superiority in front of colored people. Mary was forbidden to play with the Greek girl during her childhood because her mother said that both of the girl's parents were dagoes. At the same time, Mary was also told to stay away from the black natives, because the blacks were "nasty and might do horrible things to her" [3]. After Mary married Dick, influenced by other farmers, her attitude towards black people became even worse. At the very least, she would abuse them, and at the worst, she would beat them with a whip. Regardless of the gender and age of the colored people, the white community shows contempt and aversion towards them all the time.

In fact, Mary and her family did not have a high social status in the local area. They were even discriminated against by other white people because they were a marginal group in the colonial culture—the poor whites. In the eyes of their wealthy fellow countrymen in the colonies, they had been excluded from the British, unable to find a sense of identity, and had become outsiders and marginalized people in the colonial community[4]. Mary was caught between the indigenous people of Africa and the white immigrants of Europe, unable to stand her ground and became "the other". This cultural position had a huge impact on Mary's spiritual life. Mary attempted to break away from her identity as "the other", and thus chose to join the side of the oppressor, enjoying the privileges of the oppressor by putting pressure on more vulnerable groups[5].

The black community represented by Moses was a typical example of persecution by the colonial system. The first black man that Mary saw in the farm was Samson, the old servant in the house. At first, she was annoyed when she heard Dick call him "bad old swine", thinking it was a casual attitude of not treating black people as human beings. However, years later, she began to beat and scold them. After Dick fell ill, Mary had to go to the fields to look after the farm work. At first, she hated interacting with black people, but she fell in love with this job because she could give orders to many black people at will. She threatened and suppressed the workers, relishing the thrill brought by this power, and even couldn't help but raise her whip and strike the face of Moses. The change in Mary's attitude towards the black servants is evident. As long as they were in such an environment, the colonists naturally developed a sense of white superiority and naturally oppressed the colonized. Such an idea promotes an either-or value choice, which is bound to lead to the disorder within the human civilized world and in the relationship between humans and nature [7]. Later, Moses worked as a servant in Mary's house. The long time spent alone together made Mary develop a special feeling for Moses in her heart, but at the same time, she felt as if Moses' touch on her had smeared her body. In this way, while Mary was secretly flirting with Moses, she also revealed her contempt for him

in her words and deeds.

Other white people were also very disgusted with Moses. For instance, because the farmer Charlie noticed that the conversation between Mary and Moses did not show any class differences, he suggested that Dick drive Moses away. Tony, a self-proclaimed progressive youth, declares that their intimacy "would be rather like having a relation with an animal, in spite of his progressiveness"[8]. Although the forbidden relationship between Mary and Moses to some extent reflected Mary's challenge to the patriarchal system and racial boundaries, her tragic ending still demonstrated the insurmountable nature of identity. Lessing took the master-servant relationship between Mary and Moses as a microcosm of the relationship between colonialists and the vast number of black slaves, providing an impartial and positive perspective on colonialism and racial discrimination, and ruthlessly lashed out at the mistakes and tragedies of this colonial era[9].

In *The Grass is Singing*, although the oppression of black women is not the main plot, it is profoundly presented through implicit depictions of social structure, racial system and character interactions. For feminists, "efforts should be made to understand how gender, race and class converge to form the overall destiny of women"[10]. Under the colonial system, the oppression suffered by black women was multi-layered. They were not only oppressed by race but also victims of the patriarchal society. In the novel, black women are constantly in a state of "speechlessness". They almost lack independent images and voices and only exist as a group image as the background. Even the black man Moses had a series of interactions with his white employer, while black women could only silently work in the fields or whisper in the corner, remaining at the end of the power chain, which reflects the low status of black women. The white community not only relied on black maids to keep the farms running but also held them in contempt due to their sense of racial superiority, reflecting the persecution of black women by the colonial system.

2.2 Oppression by Patriarchal Culture

Mary's short life was deeply oppressed by patriarchal culture. In Mary's family, her father spent most of his salary on drinking and showed no concern for his children. Every day at home, her mother mended clothes and cried to others about her father's uselessness. However, Mary and her mother could only endure her father's behaviors, because "He's a man, isn't he? He can do as he likes"[11]. Influenced by the patriarchal ideology, even though Mary had a brief period of financial independence after reaching adulthood, she was never able to achieve true spiritual independence. In a patriarchal society, women can only silently endure the oppression brought by men because they are constantly instilled with the idea that being a good wife and mother at home is their mission. When all male-dominated thinkers and theorists defend the history, reality, system and ideology of men ruling over women, what they say is: Is it God or nature that forces women to submit to men? They marginalize women by endowing men with certain qualities (rationality, logic, intelligence, soul) and women with others (chaotic emotions, uncontrollable sexual desire, etc.). The logic of male chauvinism does not directly say anything about women, but rather uses tactful words to conceal its true meaning. When it aims to maintain the existing system and prompt women to submit to men, it employs slogans such as "protecting the family"[12].

Influenced by her family and social environment, Mary, at the age of thirty, gave up her high-paying job and, with the aspiration of "getting close to nature", resolutely chose to marry Dick, a small farmer. However, Dick's family was extremely poor. The farm he had been struggling to manage suffered losses year after year. Although Dick had the idea of changing the situation, he always gave up halfway. Mary chose to escape from the predicaments of reality many times, but after experiencing countless disappointments, she became resigned to her fate and entrusted her destiny to her husband, who she could not rely on at all. At a loss about the current situation, Mary simply wanted to save herself by having a baby and find something to do for herself. However, Dick, on the grounds of being poor and unable to afford the expenses of giving birth, coldly denied Mary's right to become a mother. "Women have been reduced to the status of a minority by a male-dominated society, although their importance in terms of numbers, and even more significantly in terms of reproduction, should have permitted them a dominant role"[13]. Mary had given up all expectations for the economic situation, but was rejected when she sought a new spiritual refuge. In this way, Mary was once again oppressed by the patriarchal culture and passively accepted her fate, which undoubtedly dealt a heavy blow to her mental state. Finally, Mary's death was the ultimate manifestation of male-dominated persecution, and her tragic ending profoundly revealed the systematic destruction of women's spirit and body by the patriarchal system. Mary had nothing, neither in terms of economic wealth nor spiritual support. In the end, even her life was ruthlessly ended by a man. It is evident that her life was always under the absolute control of men, with no chance for independent choice at all.

In conclusion, Doris Lessing, through the tragic fates of Mary and Moses, profoundly analyzed the destructive effect of the oppressive structure of colonialism and patriarchy on individuals, and demonstrated how oppression leads to the universal alienation of human nature. Whether it is Mary's mental breakdown and ultimate death, or Moses' transformation from a victim to an abuser, they were

all extreme manifestations of the distortion and destruction of human nature by this systemic violence. Colonialism and patriarchy jointly created a cage of alienation and destruction that no one could truly escape.

3. ECOLOGICAL WASTELAND UNDER ANTHROPOCENTRISM

Modern western ideology is based on the value of rationality supremacy. It emphasizes the rationality and autonomy of human progress. Under the premise of being human-centered, it places human beings and nature in a separated or even opposing relationship [12]. On the contrary, ecofeminism holds that holism is the inevitable choice for the social progress movement to reach a higher stage. Only by viewing every issue from all dimensions can it be possible to solve problems thoroughly. As early as the 16th and 17th centuries, the organic view of nature was still widely popular in western society. However, with the development of capitalism, "the expansion of capitalism with the industrial revolution connects: technological advancement; the attendant change in political economy; the realization of many of the ambitions of the Enlightenment science; and the enabling of unprecedented exploitation of the natural world" (Lara Stevens, 2017: 2). From the perspective of anthropocentrism, nature is not an organic whole with vitality, but rather a materialized object that humans exploit endlessly to meet their own needs. With the deepening of industrialization, human exploitation of natural resources has gradually intensified, triggering a series of ecological and environmental problems.

In terms of human's attitude towards land, farmers have a distinct tendency towards male chauvinism and anthropocentrism. These farmers who rely on the land to support their families do not truly love the land and nature, instead, they use nature as a tool to make money. This is vividly demonstrated in the case of the farmer Charlie. Charlie made a fortune during World War I due to the soaring price of corn, and thus wanted to expand his land by taking over Dick's small farm. But he almost never takes care of this land on which he depends for survival. "He was careful not to invest his money in farming....He did not improve his farm more than was essential for the purpose of making money from it..." (Doris Lessing, 2013: 155). Ecological critic Wang Nuo believes that human society is one of the most important subsystems of the ecosystem, and humans are the most destructive and constructive components of the ecosystem....The harmony of the entire ecosystem cannot be achieved without the harmony within human society. Without harmony, human society cannot have a harmonious world either (Wang Nuo, 2013:164). Charlie's cruel exploitation of the land is bound to cause a series of ecological problems. The drought and other natural disasters mentioned in the text may just be a trigger. One day, the people on this land will surely bear the punishment of nature.

The change in Mary's attitude towards the land in the text contains profound meaning. Ecofeminism holds that the sense of closeness between women and nature stems from the similarity in their oppressed positions under male chauvinism and anthropocentrism, and this similarity in turn stems from the fact that the two oppressives follow the same set of ruling logi[4]. However, a similar marginalized fate did not lead Mary to view nature as her "ally". Passively accepting the dualistic thinking mode, she continued the ruling logic of the dominant dualism, distancing herself from, fearing, and even hating nature [14]. Mary initially detested the African savannah. The so-called "closeness to nature" she referred to when getting married was learned from a sentimental novel, and she did not truly love nature from the bottom of her heart. When they first got married, Mary only looked down upon Dick's way of running the farm and the hundreds of acres of trees he planted. She merely regarded the farm as a tool for making money. But years later, she found that she had already become dependent on the farm just like Dick. The current state of the farm also had an impact on her, making her think in terms of the next season [4]. At the end of the article, Mary, who was tormented by a poverty-stricken real life and an empty and lonely spiritual life, truly devoted herself wholeheartedly to nature on her last day of life. "She crouched against the sill, cramped and motionless, clutching on to her last remnants of happiness, her mind as clear as the sky itself "[4]. Perhaps because she was about to leave this dilapidated farm and had finally ended her forbidden love with Moses, Mary, who had lived on this land for many years, was enjoying the beauty of nature for the last time in a relaxed state. It is evident that when humans are single-mindedly demanding of nature, they cannot integrate into it. Unrestricted exploitation and plundering will only prompt nature to retaliate against human tyranny with a harsh living environment. Human beings and nature should coexist in harmony, and humans should always be grateful for the gifts of nature. However, for a long time, humans have relied on anthropocentrism to guide their actions, believing that they will eventually become the masters of nature and viewing their relationship with nature as one of domination and being ruled. Human beings' wanton destruction of nature has already caused serious ecological problems both in novels and in real life. Eventually, humans will have to pay the price for their actions.

4. CONCLUSION

Doris Lessing moved to a farm in Southern Rhodesia with her parents when she was young, and thus has always maintained a close connection with nature. In The Grass *Is Singing*, Lessing, through this tragedy that occurred in an African colony, mercilessly criticizes the oppression of humanity by colonialism

and patriarchy and the oppression of nature by humanity. Lessing believed that whether it is patriarchy placing women in a subordinate position through the gender power structure, colonial culture systematically oppressing colonial people under the guise of "civilization superiority theory", or human beings' excessive exploitation of nature, they are essentially different manifestations of the same logic. She called for breaking this oppressive system and advocating an ethical relationship of equality and symbiosis. Whether it is gender, race or the relationship between humans and nature, a harmonious order should be built on the basis of respecting differences.

Just as Mary did not escape the oppression of male chauvinism, the indigenous black people in the colonies did not escape the oppression of the colonists, and the land of South Africa is still enduring the endless exploitation by humans. Mary died in the gap between chauvinism and the colonial system, Moses lost his dignity under the rule of the white, and the African continent gradually declined in predatory reclamation. Lessing's writing is not only an accusation against the evil of history, but also a warning to modern society: when the power structure continues to create opposition between "us" and "others", whether it is gender, race or the relationship between man and nature, it will eventually lead to self-destruction in endless exploitation. Perhaps, only by breaking this binary opposition can the oppressed be reborn.

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The Aesthetic of Atmosphere in Hawthorne's *The Scarlet Letter*

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Abstract: American writer Nathaniel Hawthorne creates an atmosphere through the three elements of color, space, and light in *The Scarlet Letter*. He portrays the psychological space of the characters, deepens the thematic implications of the work, and reproduces the life in a Puritan town in the 17th century where the religious laws are strict. He also depicts the painful struggles of the protagonist Hester Prynne under moral, romantic, and social pressures. On the one hand, the author makes extensive use of colors with symbolic meanings such as red, black, gray, and white to create an atmosphere that is both oppressive and heavy, yet also contains hope and redemption, thus shaping the main characters. On the other hand, the author carefully constructs "textured spaces" such as the scaffold, Hester's cottage, and the forest, creating an oppressive, dull atmosphere with a touch of mystery and struggle, which drives the development of the plot. In addition, the author ingeniously uses natural light, contrast between light and darkness, and shadows and other techniques to create an atmosphere of oppression, redemption, etc., enriching the charm and aesthetic appeal of the text. Böhme's aesthetics of atmosphere focuses on the interpretation of atmosphere as an aesthetic phenomenon, and its mediating function between the subject and the environment, with the characteristics of spatiality and emotionality, opening up a new path for the interpretation of literary works. Based on this, this paper analyzes the specific atmosphere created in The Scarlet Letter, excavates the multi-layered emotional connotations in aspects such as human nature, morality, and religion, reveals the oppression and distortion of human nature in Puritan society, and showcases the enduring literary charm and profound ideological connotations of the work.

Keywords: *The Scarlet Letter*; Color; Space; Light; Aesthetics of Atmosphere

1. INTRODUCTION

Nathaniel Hawthorne's masterpiece *The Scarlet Letter* is a classic of American literature. Set in Puritan New England of the seventeenth century, the novel establishes an atmosphere that is repressive, tense, and saturated with religious color. Through meticulous environmental description, incisive characterization, and rich symbolism, Hawthorne fashions a society rigidly bound by religious and moral codes. The narrative follows Hester Prynne, who is condemned to wear a scarlet "A" on her bosom for adultery; this emblem of shame exposes the hypocrisy and cruelty of Puritanism and its suffocating effect on human nature. The novel thereby provokes sustained reflection on morality, law, human rights, and humanity itself, exerting a profound influence on later literature and social thought. Since its publication, scholars have approached the text from multiple angles. Traditional studies have focused chiefly on the symbolic meanings of the scarlet letter, the moral subject, and feminist readings; few have examined the work through the lens of "atmospheric aesthetics."

The concept of "atmospheric aesthetics" was first introduced by Gernot Böhme in Für eine ökologische Naturästhetik. In a parallel development, beginning in the 1960s, German neo-phenomenologist Hermann Schmitz incorporated atmosphere into phenomenology, grounding it in a phenomenology of the body and interpreting atmosphere as an aesthetic phenomenon, thereby deconstructing and reconstructing it within aesthetics[1][1]. Böhme defines "atmosphere" as the peculiar intermediary status of atmospheres between subject and object[2]. They are affective powers of feeling, spatial bearers of moods[2]. This view transcends the traditional subject–object binary and resolves the ontological problem of locating atmosphere. From this foundation Böhme turns to the production of atmospheres, investigating color, space, music, light and shadow, and the aestheticization of everyday life.

This paper adopts the perspective of atmospheric aesthetics to analyze Hawthorne's sophisticated atmospheric techniques in The Scarlet Letter. Focusing on color, space, and light/shadow as key atmospheric elements, it explores how the text constructs mood and examines the ways in which atmosphere shapes character portrayal, deepens thematic concerns, and propels narrative progression.

2. COLOR AND ATMOSPHERE CONSTRUCTION IN *THE SCARLET LETTER*

Friedlind Riedel summarizes in her article "Atmosphere" that """Atmosphere" refers to a feeling, mood, or Stimmung that fundamentally exceeds an individual body and instead pertains primarily to the overall situation in which bodies are entrenched"[3] (Jan Slaby, Christian von Scheve, 2019: 85). Color is one of the key elements in constructing atmosphere. Through the interaction of its own physical properties and psychological effects with space, time, light, emotion, and culture, it creates specific perceptual

experiences and emotional resonance, thereby shaping a unique atmosphere. Böhme argues that the rendering of colors in the visual field, which shrouds an entire landscape or scene like a veil, essentially constitutes a transformation of the overall color composition, and this is precisely the true field where colors generate sensory-moral effects. While the color of an individual object may affect the viewer's mood-for instance, the visual presentation of a yellow dress might lift the observer's spirits-the sensual–moral effect is actually something more atmospheric. It is the emotional tint
of the space in which one finds oneself that determines how one feels[2]. (Böhme, 2017: 202).In literary works, color plays an important role. It can help authors construct scenes, set off the atmosphere, and make characters' images more vivid and three-dimensional. Color has different symbolic meanings in different contexts, enabling readers and writers to resonate across time and space through words, thus endowing literary works with higher aesthetic value[4] (Zhou Yingchao, 2023: 28). In The Scarlet Letter, Hawthorne skillfully uses colors such as red, black, gray, and white. This not only constructs a unique atmosphere but also deepens the character images, successfully revealing the complexity of human nature and the dark side of society, and endowing the work with rich symbolic significance and artistic appeal.

2.1 Red: Sin and Redemption

Red is the most conspicuous chromatic thread in The Scarlet Letter, weaving through the entire novel to evoke a spectrum of atmospheres. At the book's opening, Hester Prynne is led to the scaffold for the crime of adultery. She stands upon the platform, encircled by a dense throng. The Puritans' faces are cold and severe, their eyes cutting like blades as they survey her, as though she were an outcast whom society has already condemned. The women are especially merciless, assailing her with venomous tongues, their voices bristling with wrath and contempt, as though intent on flaying her alive. "On the breast of her gown, in fine red cloth, surrounded with an elaborate embroidery and fantastic flourishes of gold thread, appeared the letter A"[5] (Hawthorne, 1850: 6). The color red-vivid, arresting-has long carried connotations of "sin" within a religious context. In the Book of Revelation the seer beholds "a woman sitting upon a scarlet coloured beast…arrayed in purple and scarlet colour…And upon her forehead was a name written, MYSTERY, BABYLON THE GREAT, THE MOTHER OF HARLOTS AND ABOMINATIONS OF THE EARTH"[6] (Project Gutenberg, 2011: 2166). Rendering the adulteress's mark in scarlet instantly rivets every gaze; it is a public chastisement and a warning. The scarlet letter on Hester's bosom is not merely a visual sign but "a burning heat" that scorches both wearer and observer with the weight of its redness. Here red is more than the emblem of "Adultery"; it diffuses through the air as a palpable "atmosphere of transgression." As Böhme remarks, color "fills space and defines affect." This chromatic atmosphere allows readers to feel the immense pressure crushing Hester and the agony churning within her, while simultaneously exposing the Puritan community's suffocating repression of human nature. Yet the same hue later engenders an atmosphere of courage and defiance. As the narrative unfolds, Hester's quiet labors of charity cause the letter to gleam with an unearthly radiance, suffusing the scene with warmth. That warmth is the outward manifestation of her inner ardor and tenacious love of life; it testifies to her refusal to surrender even when marginalized and oppressed. The scarlet emblem gradually becomes the very embodiment of her resilient power. At the moment of Dimmesdale's death, he clasps Hester's hand and proclaims that the scarlet letter on her breast is but the shadow of the one etched upon his own. Ripping open his vestment, he reveals the stigma seared into his flesh. In this climactic instant, the red of the letter creates an atmosphere of passion and revolt. Readers sense the minister's torment and, at last, his victory over self, his courageous acceptance of responsibility-an apotheosis of inner struggle and redemption.

2.2 Black and Gray: Oppression and Heaviness

Throughout the novel, scenes dominated by black and gray tones recur with relentless insistence. The turnkey is a "black shadow"; the prison itself is "the black flower of civilized society"; the crowd that waits outside its gate wears "sad-colored garments and gray, steeple-crowned hats." These frigid hues form a mobile tribunal of signs. The very moment Hester steps into view she is imprisoned within a sensory cage, crushed by the weight of their drabness. When Dimmesdale mounts the scaffold by night, the viscous darkness drips over him like liquid ink, seeping along his shuddering spine until every hidden pang of remorse is roused. This embodied description forces the reader to share his suffocation. The forest's gloom is an even more deceptive sensory hallucination: the interlacing shadows knit a vast black net that muffles every whispered confession, while the creaking boughs resemble the peepholes of an unseen confessor. The materiality of blackness here silently reminds us that Puritan ethics have become a reflex of the nerves; even the wilderness, ostensibly the realm of freedom, has been alienated into an instrument of discipline. These somber tones flatten visual experience into monotony and repression. Both Hester and Dimmesdale feel themselves perpetually watched and judged; the atmosphere thickens with heaviness. Readers are drawn to sympathize, sensing how Puritan society fetters human nature under the guise of morality, branding every desire, feeling, and weakness as sin. The drabness that envelops Hester's public shaming materializes this oppressive mood; her transgression

seems irremediably steeped in it. The recurrence of black and gray also signals an unending moral trial and spiritual imprisonment. Black is further linked to suppressed, leaden emotion. Dimmesdale's nocturnal vigil on the scaffold illustrates the point: the night's visual darkness is bottomless, provoking dread and speculation, tightening suspense and unease. Here the black-gray palette externalizes the minister's tormented psyche, foreshadowing the tragic fate his inner conflicts make inevitable. The forest's darkness conjures mystery, menace, and the unknowable. Tension gathers around every future event; danger feels imminent. Although Hester and Dimmesdale contrive an escape beneath those trees, they cannot elude the moral coils of their society or the coils of their own guilt. Their story ends in catastrophe. The dark sky and darker woods become emblems of social oppression and private agony; every action and emotion is freighted with difficulty, and the reader feels the immense pressure bearing down upon them.

Roger Chillingworth, Hester's husband, is cast as the avenger. Hawthorne clothes him in black as well. When he first appears, his face is smoked black by the "infernal fires" of his laboratory, and his garments are always sable. Black denotes the murky and the inscrutable; Chillingworth glides like a specter in the shadows, secretly probing the minister's heart. His presence breeds unease. Obsessed by revenge, he metamorphoses into a devil, intensifying the novel's terror and oppression, and saturating the narrative with a gloom that reeks of malevolence.

2.3 White: Purity and Hypocrisy

In the novel, white is repeatedly linked to Pearl and Dimmesdale. Pearl is habitually dressed "like a white rose." Although her birth is branded as the fruit of "sin," the child herself is innocence incarnate. Her white garments stand out sharply against the drab clothing of the townspeople, visually marking her as an "other" and creating an atmosphere of chaste estrangement. On the Reverend Dimmesdale, white evokes oppression, anguish, frailty, and enigma. A Puritan minister who has fathered a child with Hester, he is compelled by circumstance to bury the secret in his heart. The resulting torment is incarnated in his pallid complexion. His ashen face transmits an almost palpable spiritual pressure to the reader, generating a suffocating mood. The pallor accentuates his physical decline and, simultaneously, hints at the despair and helplessness within. The very whiteness that ought to suggest purity here becomes the hue of a soul corroded by duplicity. Dimmesdale's waxen skin renders him spectral, cloaking him in mystery. The townspeople watch his failing health with anxious curiosity yet can never penetrate his inner world; suspense thickens. This aura of secrecy reflects the Puritan society's repression of human nature and the labyrinthine, hidden selves it breeds.

Throughout The Scarlet Letter Hawthorne deploys color to conjure distinctive atmospheres and deepen characterization. The scarlet A oscillates between emblem of sin and token of redemption: from Hester's brand of shame, to the banner of her defiance, to the mirror of Dimmesdale's inner struggle and eventual salvation. Shades of black and gray construct an oppressive environment-prison, forest, night-scaffold, somber clothes-symbolizing Puritanism's fetters and judgment. White, associated with Pearl's purity and Dimmesdale's hypocrisy and pain, sets up stark contrasts that foreground individual traits and societal duplicity. These chromatic strategies not only enrich the novel's symbolism but intensify its emotional force, allowing readers to feel both the characters' inner worlds and the suffocating atmosphere of their society.

3. SPACE AND ATMOSPHERIC CONSTRUCTION IN *THE SCARLET LETTER*

Henri Lefebvre argues that "space is essentially a production… it is produced as a tool of thought and action… space is not only a mode of production but also a mode of control, signifying domination and power"[7] (Lefebvre, trans. Liu Huaiyi, 2021: 83). Gernot Böhme similarly maintains that today atmosphere may be defined briefly as tuned space, i.e. a space with a certain mood[2]. (Böhme, 2017: 2). Böhme's atmospheric aesthetics focuses on the felt situatedness-the bodily "being-there"-of human subjects and their relation to surrounding space. As Tonino Griffero observes in Atmospheres: *Aesthetics of Emotional Spaces* (2014), the perception of atmosphere involves not merely corporeal presence but also the emotions intimately bound up with that embodied presence [8](Griffero, 2014: 7). In The Scarlet Letter, Hawthorne constructs distinct atmospheres through carefully delineated spaces. These spaces do more than advance the plot; they deepen the novel's themes and render the characters' inner lives with extraordinary intensity.

3.1 Hester's Cottage

After leaving the prison, Hester took up residence in an abandoned thatched cottage. "It stood on the shore, looking across a basin of the sea at the forest-covered hills, towards the west. A clump of scrubby trees, such as alone grew on the peninsula, did not so much conceal the cottage from view, as seem to denote that here was some object which would fain have been, or at least ought to be, concealed."[5] (Hawthorne, 1850: 26). As a space that can be occupied by an individual, a living space reveals the occupant's life circumstances and personal consciousness[9] (Liu Lu, 2019: 12). The cottage, located on the coast, surrounded by only a few clumps of stunted trees and enclosed by forests and hills, is geographically isolated. This remoteness symbolizes Hester's marginalized and alienated position in society. Such an environment creates an atmosphere of loneliness and desolation, mirroring her isolation and exclusion. Forced to live apart from the community in this

abandoned place, she embodies the loneliness and helplessness within her. The description of the cottage, which cannot be fully hidden by the scrubby trees, suggests that although Hester is socially ostracized, she can never fully escape society's gaze and judgment. It is well known that housing, clothing, and the like are symbols of wealth and status, carriers of meaning, and projections of the psyche[10] (Wegmann, 2016: 40–60). Hester's cottage resembles Foucault's "panopticon"-"a circular building with a central tower; the cells are distributed around the circumference, each with two windows: one facing the inside, towards the tower, and the other towards the outside. A single supervisor in the central tower can observe all the prisoners in their cells, while the prisoners cannot see the observer"[11] (Foucault, trans. Liu Beicheng & Yang Yuanying, 1999: 230). Fixed in her position, Hester becomes a socially marked "target," an object of disciplinary power, constantly reminded of her sin.This description of a concealment that only draws more attention creates an atmosphere of oppression and secrecy, as if the cottage harbors an unspoken secret-one as intolerable to society as Hester's "sin," something that can only be hidden in half-measures.

3.2 The Forest

The forest is a significant setting in the novel. There, Hester and Dimmesdale sit side by side on a moss-covered tree trunk, holding hands, pouring out their hearts, and planning their future. At this moment, "The forest was obscure around them, and creaked with a blast that was passing through it. The boughs were tossing heavily above their heads."[5] (Hawthorne, 1850: 111). The dimness of the forest blurs spatial boundaries, making it hard to discern surrounding objects. This obscurity creates an atmosphere of mystery and danger, serving as a natural filter for sin. Hawthorne uses the "dim forest" to weaken spatial boundaries, placing Hester and Dimmesdale in a chaotic visual field. The indistinct outlines and impenetrable shadows in the depths of the dense woods disorient their physical perception, mirroring their psychological disorientation. This visual uncontrollability symbolizes the invisibility of sin-it is not a tangible fetter but permeates the characters' skin and breath like mist, making readers feel the same oppression and suffocation. The rustling whirlwind and heavily swaying branches form a dynamic auditory violence. Hawthorne evokes physiological unease through the unpredictability of sound: the howling wind tears through tranquility like the lashing of Puritan doctrine on the soul, while the friction of branches resembles invisible hands rending moral facades. This auditory oppression directly affects the characters' physical reactions-Hester's voice grows hoarse, and Dimmesdale trembles all over. Their physical trembling resonates with the natural sounds, materializing the threat of sin into an audible, tangible reality that immerses readers in the scene. "One solemn old tree groaned dolefully to another, as if telling the sad story of the pair that sat beneath, or constrained to forbode evil to come" [5](Hawthorne, 1850: 111). The old tree, endowed with "solemnity" and "sorrowful groans," turns nature into an accomplice and judge of sin. The trees' groans are both vibrations in physical space and echoes in psychological space. When the old tree's suffering resonates with the characters' "sad tale," the forest ceases to be mere background and becomes an active "entity of sin" participating in the narrative-its groans cut through their disguised visions of happiness, hinting at Hester and Dimmesdale's fate. Despite their brief taste of freedom and hope in the forest, they remain bound by society and their own consciences, their destiny seemingly predetermined. Through the old tree's groans, this description creates a heavy, sorrowful atmosphere tinged with fatalism, allowing readers to emotionally experience the fall from hope to despair. This "complicity" between nature and humanity reinforces the inescapability of sin, enhancing the story's emotional tension and deepening its exploration of fate and tragedy. In the dark night sky and forest, the characters appear particularly small and lonely-a loneliness stemming not only from the vast, empty physical space but also from their inner helplessness. Trapped as if in darkness with no escape, they evoke a sense of despair that elicits deep sympathy from readers.

3.3 The Scaffold

As a crucial setting in the novel, the spatiality of the scaffold plays a key role in shaping the atmosphere. The scaffold first appears at the beginning of the story, where Hester, holding Pearl, is publicly displayed. Surrounded by townsfolk pointing and murmuring, "The unhappy culprit sustained herself as best a woman might, under the heavy weight of a thousand unrelenting eyes, all fastened upon her, and concentrated at her bosom." [5](Hawthorne, 1850: 9). Foucault noted in Discipline and Punish: The Birth of the Prison that "in the ritual of public execution, the main role is played by the people. Their concrete and direct presence is necessary for the ceremony"[11] (Foucault, trans. Liu Beicheng & Yang Yuanying, 1999: 63). This gaze of onlookers, scrutiny, and judgment fills the entire space with an atmosphere of oppression and heaviness.Beyond the stares of ordinary townsfolk, the town's dignitaries also stand on the balcony of the meeting-house, overlooking her. The vertical spatial arrangement-balcony above, scaffold below-creates an atmosphere of oppression and humiliation. This high-low disparity places Hester in a position of obvious inferiority: authorities like the governor and clergymen, looking down from the balcony, assume a god-like posture of judgment. Hester, standing on the lowly scaffold like a "lamb to the slaughter," is subjected to intensified judgment by this physical gap, enduring immense psychological pressure under public gaze, her helplessness and

insignificance emphasized, and she is shrouded in deep humiliation. As Wang Min'an observes, if this power has a mode of expression, it manifests not as ostentatious or exaggerated violence, but as the inherent gaze within a system of inspection[12] (Wang Min'an, 2002: 197). The stares surrounding the scaffold form an inescapable cage, creating a suffocating sense of oppression.The second appearance of the scaffold occurs at midnight, when Dimmesdale, driven by inner torment and guilt, climbs onto it. The dark spatial environment creates an atmosphere of mystery and loneliness. The night shrouds his form but amplifies his perceptions; the dim moonlight, cold night wind, and rumbling sounds of the deep night all become carriers of sin. Hawthorne skillfully employs the aesthetic technique of "developing images through darkness": when vision is obscured by darkness, other senses grow sharper. The enclosed nature of darkness plunges the clergyman into sensory overload, allowing him to perceive the subtle tremors of sin more acutely. Here, the scaffold shrinks from a public tribunal to Dimmesdale's inner court, drawing readers into a psychological montage: his cries under moonlight, his trembling after taking Pearl's hand, the dark red "A"-together, they construct a sensory montage of sin, shifting the reading experience from external observation to internal empathy.

The third appearance of the scaffold comes at the end, when Dimmesdale, after delivering his sermon, invites Hester and Pearl to stand with him on it. He confesses his sin publicly before dying on the scaffold. At this moment, the scaffold, no longer Dimmesdale's inner court, reverts to a space of public judgment-but the "triangular space" formed by the three of them breaks the traditional vertical power structure. The scaffold transforms from a mere "pillory of shame" to an "altar of redemption"; the dissolution of physical height symbolizes the collapse of moral hierarchy. Dimmesdale's public confession on the scaffold frees him from long-term inner torment, completing his self-redemption. This scene is filled with an atmosphere of liberation and rebirth, symbolizing the characters' inner growth and transformation. The scaffold is not merely an execution site but a microcosm of Puritan society. Through these three distinct depictions of the scaffold, Hawthorne not only creates atmospheres of oppression, mystery, tension, and hope but also reveals, through spatial shifts and character interactions, the collective violence perpetrated by Puritan society in the name of morality, deepening the novel's themes.

Space in The Scarlet Letter functions to create atmosphere, advance the plot, delineate the characters' psychology, and deepen the novel's themes. Hester's cottage, set in an out-of-the-way spot, symbolizes her social isolation and generates an atmosphere of solitude and oppression. The forest-veiled in haze, filled with muffled sounds, and haunted by the "groans" of ancient trees-hints at transgression and evokes an atmosphere at once mysterious, perilous, and freighted with fatal sorrow. The scaffold appears three times, each occasion producing a different mood: first humiliating and oppressive, then secretive and lonely, and finally liberating and redemptive. These spaces expose the collective violence of Puritan society and reveal how disciplinary power shapes-and warps-human nature.

4. LIGHT

Gernot Böhme observes that "darkness and brightness alter our bodily situatedness in perception-widening or narrowing the felt conditions of our existence, whether those conditions be oppressive or joyful" [13](Böhme, 2018: 123). In The Scarlet Letter, Hawthorne's descriptions of light function not merely as atmospheric backdrop, but as a profound metaphor for the conflicts among human nature, morality, and religious authority. Through chiaroscuro, shifting chromatic values, and moving patterns of illumination, he renders abstract moral judgments as vivid visual images, constructing a symbolic universe charged with tension.

4.1 Sunlight and Moonlight on the Scaffold

When Hester first mounts the scaffold, "the hot mid-day sun burning down upon her face, and lighting up its shame; with the scarlet token of infamy on her breast"[5] (Hawthorne, 1850: 13). Sunshine is usually associated with warmth and comfort, yet the word "burned" endows it with aggression. The scorching midday rays become a physical extension of the Puritan community's collective gaze; the tangible smart of heat figures the soul-scorching violence of moral judgment. Forced into the full glare, Hester is stripped of privacy: the inescapable brightness parallels the exposure exacted by Puritan ethics. Pain is not merely epidermal; the burning cheek and blazing shame are fused into bodily memory. Beneath both public stare and solar fire she suffers a double torment of flesh and spirit, her transgression and punishment exposed without refuge. Rudolf Arnheim observes that "light is perhaps the most magnificent and overwhelming experience the senses can receive"[14] (Arnheim, 1974: 303); Hawthorne's handling of light thus intensifies the stifling, humiliating atmosphere of the scene. Later, when the minister keeps his nocturnal vigil with Hester on the scaffold, "a light glanced far and wide over the cloudy sky. So powerful was its radiance, that it thoroughly illuminated the dense medium of cloud betwixt the sky and earth."[5] (Hawthorne, 1850: 79-80). Against the oppressive backdrop of piled darkness, that remote and sweeping radiance breaks the night's stillness and creates an atmosphere at once mysterious, solemn, and supernatural. The sudden blaze violates the natural order of light and shadow, functioning as a visual metaphor for transcendent intervention. The diffused illumination that filters

through the clouds bathes the scene in a pantheistic panopticon; the meteoric flare becomes Hawthorne's most theologically charged moment of judgmental lighting. It is as if the scaffold has been transformed into a sacred tribunal. The light pierces not only the surrounding gloom but also the souls of minister and sinner: "the light that is to reveal all secrets, and the daybreak that shall unite all who belong to one another" [5](Hawthorne, 1850: 80). Its revelatory power elevates private guilt to the dimension of a cosmic ethical event. Under this unearthly glare, Chillingworth's malignant stare, the minister's hallucinated scarlet letter, and Hester's burning emblem receive equal exposure. Hawthorne thereby declares that the more a transgression seeks concealment, the more vividly it stands revealed beneath the eye of divine light. The meteor's brief but fierce illumination is the instant verdict of moral conscience upon hidden sin, endowing the scaffold with an aura of mystery, disclosure, psychological tension, and moral conflict. When the minister at last confesses his guilt upon the scaffold, "the sun, which had just passed the meridian, shone full upon him, making his figure very distinct" [5](Hawthorne, 1850: 154). The noonday sun now creates an atmosphere of sacred redemption. Its perfect vertical descent forms a geometry of sacral projection; the minister's outline is etched in brilliant clarity, suggesting that moral stain can find no recess in absolute light. This solar configuration carries a double valence: it is at once the final torch of Puritan judgment and the redeeming radiance by which a natural divinity receives confession. Hawthorne thus dismantles any single-directional reading of light: the same fierce sun that in the opening scene abets collective violence becomes, in the closing scene, the very medium through which the individual transcends social law. The minister's body, rendered transparent by the flood of light, undergoes ultimate exposure of a seven-year hidden guilt, yet it also attains spiritual purification through public self-revelation.

4.2 Chiaroscuro in the Forest

On a path sunk in gloom, Hester grips Pearl's small hand and steps cautiously forward. She is resolved to disclose a truth long coiled like a serpent beside the minister: the physician who haunts him is her long-lost husband. The forest lies under a pall of darkness; the scant sunlight cannot brighten its melancholy depths. "The sportive sunlight-feebly sportive, at best, in the predominant pensiveness of the day and scene-withdrew itself as they came nigh, and left the spots where it had danced the drearier, because they had hoped to find them brigh"[5] (Hawthorne, 1850: 101). Hawthorne makes the sombre woods the very vessel of transgression, and he heightens their emblematic force through oppressive alternations of light and shade. As Hester moves beneath the canopy, the faint rays are splintered by branches into fragments; the paradoxical result is that the places the sun touches appear darker still. This inversion of normal illumination figures the occlusion of truth by Puritan doctrine-the light that should redeem instead deepens the scarlet shadow of her "adultery." The forest is not merely a physical setting but the materialization of social discipline and the shackles of conscience. Hawthorne deliberately renders the light impenetrable to mirror the weight of guilt. The brittle gleams and surrounding murk create a stark visual tension, externalizing the characters' vacillation between truth and deception, rebellion and submission. Darkness stands for the brand society has seared upon them; the scattered flecks of brightness are the last embers of human hope. Yet when Hester bids the minister not to look back and flings the scarlet letter among the withered leaves, the gloom that has clung to sky and forest lifts. Clothing is a civilized extension of the body, bearing, expressing, and transmitting all the messages of the flesh[15] (Luo Jingguo, 1981: 224); by casting off the embroidered badge Hester casts off her chains and challenges tradition. "All at once, as with a sudden smile of heaven, forth burst the sunshine, pouring a very flood into the obscure forest, gladdening each green leaf, transmuting the yellow fallen ones to gold, and gleaming down the gray trunks of the solemn trees."[5] (Hawthorne, 1850: 116). The advent of sunlight is no mere change of weather; it is the dissipation of guilt and the advent of grace. The forest, once choked with darkness, is now steeped in radiance, the glare of hope rebounding from every leaf. The contrast with the preceding gloom is so violent that Hester feels her body lighten; the burden of transgression seems to fall away, and the reader, who has shared the earlier oppression, now breathes freely in the same luminous air. Hawthorne's orchestration of light enacts a progression from heaviness to release, mirroring the transformation within the characters themselves.

Thus Hawthorne converts gradations of brightness, color, and motion into a symbolic idiom. On the scaffold, noonday sun becomes the fire of moral judgment; the meteor's flash proclaims that truth cannot remain hidden; the final, meridian glare is both verdict and absolution. In the forest, chiaroscuro first signifies the Puritan veil drawn over truth-darkness as guilt, stray gleams as hope-while the flood of light that follows the casting-off of the scarlet letter signals the dissolution of sin and the dawn of redemption, embodying the characters' inner metamorphosis.

5. CONCLUSION

In The Scarlet Letter, Hawthorne constructs a multilayered symbolic system through color, weaving red, black-gray, and white into an atmospheric tapestry that captures both the oppressive climate of Puritan society and the tangled energies of human nature. Red threads its way from shame to redemption; its visceral immediacy intensifies the

contagious aura of sin, echoing Böhme's claim that "color defines affective space." Black-gray-shrouding prison walls, nocturnal scaffolds, and Chillingworth's sable garb-materializes moral judgment as a sensory cage that devours the self, fusing somber physical settings with psychic confinement. White oscillates between Pearl's unschooled innocence and Dimmesdale's bloodless mask of hypocrisy, exposing the lacerated soul beneath clerical purity. Together the three hues render an atmosphere of simultaneous repression, struggle, and fragile hope. By orchestrating their interplay with space and body, Hawthorne transmutes abstract social discipline into palpable aesthetic experience, making color the central narrative medium for dismantling Puritan violence and exploring the possibility of human salvation.

The novel's spatial narration, entwined with atmospheric aesthetics, maps the double plot of Puritan power and human redemption. Hester's cottage-an isolated outpost on the edge of the sea-functions as a "disciplinary space": its exposed yet peripheral location converts social violence into a panoptic sensory prison, reflecting the colony's unbroken gaze upon the marginal subject. The forest, with its hazy veiling and intrusive sounds, is nature rendered accomplice to moral judgment; its chaotic sensorium promises fleeting liberty while reinforcing the invisible contagion of guilt. The scaffold's triple reconfiguration-through shifts in elevation and function-ritually moves from punitive spectacle to emancipatory rite. From the elevated platform's "God’s-eye view" to the leveled triangle of three human bodies, the deterritorialization of physical space enacts the collapse of moral hierarchy. These depictions heighten emotional tension and deepen the novel's meditation on humanity, society, and fate.

Subtle modulations of light create shifting atmospheres that stage the dialectic between Puritan ethical violence and the possibility of redemption. On the scaffold, sunlight and moonlight enact two modes of authoritative seeing: the noonday glare "burns" Hester's flesh, turning light itself into a tactile extension of the colony's panoptic gaze; the meteor's sudden blaze rends the darkness to reveal the minister's hidden guilt in a supernatural exposure. In the forest, chiaroscuro performs the visual dialectic of sin and grace. First, "skipping gleams" swallowed by gloom intimate the foreclosure of salvation under Puritan law; then, when Hester casts away the scarlet letter, a flood of radiance transmutes dead leaves to gold, reconfiguring natural light as a liberating force that shatters moral fetters. Böhme's claim that "light alters our situated feeling" is here dramatized as a kinetic politics of the senses-light as both instrument of discipline and medium of redemption. The waxing and waning of its intensity and reach compose a mobile moral theater in which readers undergo the triple experience of repression, exposure, and rebirth.

Taken together, The Scarlet Letter deploys color, space, and light as interlocking dimensions of narrative. The red-black-white chromatic system, the atmospheric interaction of spatial design, and the orchestration of illumination jointly deconstruct Puritan ethical violence, reveal the intricacies of human nature, and construct a dialectical field of oppression and redemption. Through this multidimensional artistry, Hawthorne deepens the novel's exploration of humanity, society, and destiny.

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Cognitive Mechanisms of the 5E Instructional Model: A Focus on Second Language Learning Contexts

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Abstract: The 5E Instructional Model (Engagement, Exploration, Explanation, Elaboration, Evaluation), developed by the Biological Sciences Curriculum Study (BSCS), has been widely adopted in second language acquisition (SLA) contexts for its emphasis on active learning and knowledge construction. This article examines the cognitive principles of learning that underpin the 5E model, with a specific focus on their applications in second language (L2) learning. Drawing on empirical research from the provided literature, we argue that the 5E model aligns with key cognitive mechanisms such as prior knowledge activation, deep processing, conceptual change, and retrieval practice. Each phase of the model is analyzed to reveal how it leverages these mechanisms to enhance L2 skills, including grammar acquisition, reading comprehension, critical thinking, and metacognitive awareness. The synthesis confirms that the 5E model's effectiveness in SLA stems from its systematic integration of constructivist learning, information processing, and conceptual change theories. Implications for L2 pedagogy and future research are discussed, highlighting context-specific adaptations and technology-enhanced implementations.

Keywords: 5E Instructional Model; Cognitive Principles; Second Language Acquisition; Constructivism; Conceptual Change; Information Processing

1. INTRODUCTION

The 5E Instructional Model, developed by the Biological Sciences Curriculum Study (BSCS) in 1987, has evolved from a science education framework to a versatile tool in second language acquisition (SLA) contexts [1]. Comprising five phases-Engagement, Exploration, Explanation, Elaboration, and Evaluation-this model emphasizes cyclical knowledge construction through active learner participation, making it particularly suited for L2 learning where contextualized interaction and meaningful practice are critical [1]. In SLA, the 5E model has been applied to enhance diverse language skills: grammar acquisition [2], reading comprehension [3], critical thinking [4], and spatial ability through AI-supported implementations [5]. Its effectiveness aligns with core SLA theories, such as the interaction hypothesis [6] and noticing hypothesis [7], which emphasize negotiation of meaning and awareness of linguistic gaps.

While the model's efficacy in SLA is well-documented [8], the cognitive mechanisms driving its success in language learning remain underexplored. Ruiz-Martín and Bybee (2022) linked the model to cognitive principles in science education, but their analysis did not address L2-specific processes like vocabulary retention or grammatical inference [1]. This article fills this gap by unpacking the cognitive principles underlying each 5E phase, drawing on empirical studies in SLA from the provided literature.

2. THEORETICAL FOUNDATIONS: COGNITIVE FRAMEWORKS IN SLA

2.1 Constructivism and Knowledge Construction

At the core of the 5E model is constructivism, which posits that learners actively build knowledge

through interactions with their environment and peers [9][10]. In L2 learning, this translates to learners negotiating meaning, testing hypotheses about language rules, and revising their linguistic schemas based on feedback-processes central to the 5E phases [10]. For example, during Exploration, L2 learners may collaboratively analyze a text to identify grammatical patterns, constructing understanding through discussion rather than passive absorption of rules [2].

Vygotsky's zone of proximal development further explains how scaffolding during 5E phases (e.g., teacher guidance in Explanation) helps learners master L2 skills beyond their current ability level. O'Malley and Chamot (1990) note that successful L2 learners actively use metacognitive and cognitive strategies-such as asking for clarification or comparing L1 and L2 structures-to construct knowledge, a process explicitly fostered by the 5E model's emphasis on learner autonomy and peer interaction [10]. In Behera et al.'s (2024) study, Odia-medium students working in groups during Exploration were more likely to identify and resolve grammatical misconceptions [2]. For instance, when analyzing sentences with reflexive pronouns (e.g., "they

hurt themselves"), students initially transferred L1 (Odia) structures, leading to errors. Through collaborative dialogue, they articulated their confusion, received peer feedback, and revised their understanding-aligning with constructivism's focus on social knowledge construction.

Constructivism in the 5E model also emphasizes the learner's role as an active meaning-maker rather than a passive recipient of information. This is evident in Tarawneh's (2024) reading comprehension study, where Jordanian ninth-graders did not merely receive explanations of text themes but instead constructed meaning through group discussions during Exploration, linking the text to their cultural experiences [3]. Such active construction, supported by the 5E phases, leads to deeper and more durable L2 learning.

2.2 Information Processing and Memory

Information processing theory describes how knowledge is encoded, stored, and retrieved [11], with deep processing-thinking about meaning rather than surface features-enhancing long-term retention. This principle is central to the 5E model, particularly in the Exploration and Elaboration phases. For instance, Elaboration activities that require L2 learners to apply vocabulary in new contexts promote semantic encoding, making retrieval more likely in real-world communication [12].

Vafaeikia et al. (2023) provide empirical support for this mechanism in their study of Iranian pre-IELTS students engaging in 5E-based online activities [4]. During Exploration, students analyzed argument structures in articles on global issues (e.g., human trafficking), requiring them to process text meaning deeply (e.g., identifying claims, evidence, and counterarguments) rather than merely decoding words. This deep processing involved linking new vocabulary (e.g., "trafficking," "exploitation") to prior knowledge, categorizing arguments, and evaluating their logical coherence. Such activities, aligned with the 5E model, correlated with significant gains in critical thinking (72.21% "not yet" to 11.62%) and creativity, as learners developed flexible knowledge representations that could be adapted to new tasks.

Craik and Lockhart's (1972) levels of processing model further explains why 5E phases like Exploration are effective: tasks that require learners to manipulate linguistic information (e.g., paraphrasing sentences or identifying collocations) lead to stronger memory traces than rote memorization [11]. In Tarawneh's (2024) reading comprehension study, ninth-graders who annotated texts for contextual clues (e.g., "underline words that show the character's emotion") during exploration retained more information than those who simply read passively [3]. Annotation forced deeper engagement with meaning, as students had to connect words to their semantic and pragmatic contexts-an example of the information processing mechanisms leveraged by the 5E model.

2.3 Conceptual Change Theory

Conceptual change theory explains how learners revise existing knowledge structures to accommodate new information [13], a process critical for overcoming fossilized errors or L1 transfer effects in SLA. The 5E model fosters conceptual change by first exposing learners to linguistic anomalies (Engagement), prompting them to question their current understanding, and then guiding them toward more accurate L2 representations (Explanation and Elaboration) [1].

Posner et al. (1982) argue that conceptual change requires four conditions: dissatisfaction with existing conceptions, intelligibility of new conceptions, plausibility of new conceptions, and fruitfulness of new conceptions [13]. The 5E model systematically addresses these conditions:

1. Dissatisfaction: Engagement creates dissatisfaction by highlighting gaps between learners ' current L2 knowledge and target language norms. For example, Behera et al. (2024) asked Odia-medium students to translate L1 sentences into English, revealing errors like "Mongooses likes" (overgeneralizing singular verb forms) [2]. This discrepancy sparked curiosity to resolve the error.
2. Intelligibility: Exploration provides opportunities to test new conceptions. Students in Behera et al.'s study analyzed correct English sentences (e.g., "Mongooses like to hunt together") to identify plural verb patterns, making the new rule (plural nouns take plural verbs) intelligible [2].
3. Plausibility: Explanation formalizes the new rule, linking it to familiar examples (e.g., "Cats like milk" vs. "A cat likes milk"), making it plausible.
4. Fruitfulness: Elaboration tasks (e.g., writing sentences about animals using plural nouns) demonstrate the rule's fruitfulness in new contexts.

This sequence, embedded in the 5E model, facilitates conceptual change in L2 learning. Naguib (2019) similarly found that secondary students revised their understanding of English grammar (e.g., present perfect tense) after Engagement activities exposed their misconceptions, followed by Exploration, Explanation, and Elaboration phases that addressed the four conditions of conceptual change [14].

3. COGNITIVE PRINCIPLES IN EACH PHASE OF THE 5E MODEL

3.1 Engagement

The Engagement phase activates learners ' prior knowledge and creates cognitive conflict to

motivate inquiry [1]. Activating prior knowledge-such as L1 linguistic schemas or world knowledge-provides a scaffold for integrating new L2 information [15]. For example, Tarawneh (2024) designed pre-reading activities for Jordanian ninth-graders where they predicted a story's plot based on cultural knowledge (e.g., "What would a character in our community do in this situation?") [3]. This activation helped learners make connections between known cultural contexts and new L2 texts, improving comprehension by 18% compared to students who skipped this phase.

Cognitive conflict-discrepancies between existing beliefs and new input-further drives engagement by creating a "need to know." Harmon-Jones et al. (2015) note that such conflict triggers a motivational drive to resolve inconsistencies, which the 5E model leverages to sustain learner involvement [16]. In Behera et al.'s (2024) grammar study, students were presented with English sentences that violated their L1-based expectations (e.g., "She has gone" vs. Odia's tense structure, which uses a single past tense for completed actions) [2]. This conflict prompted students to ask questions like, "Why use 'has gone ' instead of 'went'?"-driving their participation in subsequent Exploration to find resolutions.

Engagement also aligns with O'Malley and Chamot's (1990) emphasis on metacognitive strategy activation, as learners reflect on what they already know and what they need to learn [10]. For instance, Vafaeikia et al. (2023) included "KWL charts" (What I Know, What I Want to Know, What I Learned) in their online 5E activities, where Iranian students listed prior knowledge of a topic (e.g., "I know 'climate ' means weather") and questions (e.g., "How do you say 'global warming ' in English?") [4]. This metacognitive activation increased task engagement by 23% compared to traditional instruction, as learners felt ownership over their learning goals.

3.2 Exploration

Exploration involves guided inquiry, where learners interact with L2 materials to investigate linguistic patterns, test hypotheses, and collaborate with peers. This phase leverages the "levels of processing" model [11], as deeper semantic processing-such as analyzing word meaning in context-strengthens memory retention. Schmidt's (1990) noticing hypothesis further underscores its importance: learners must attend to linguistic features to acquire them, and Exploration tasks explicitly guide this attention [7].

In Vafaeikia et al.'s (2023) study, Iranian pre-IELTS students engaged in online Exploration activities using the Easyclass platform, such as identifying argument structures in articles on climate change [4]. Working in groups, they annotated texts for claims, evidence, and counterarguments, requiring them to process both content and linguistic forms (e.g., transition words like "however," "therefore"). This collaborative analysis exposed learners to diverse perspectives, prompting them to refine hypotheses through discussion [17]. For example, a group debating the use of "although" vs. "despite" clarified their understanding by comparing examples from the text: "Although it is hot, we will go" vs. "Despite the heat, we will go"-a process that deepened their grasp of conjunctions.

To avoid overwhelming working memory, Exploration is scaffolded to reduce cognitive load [18].

G ürefe et al. (2024) used AI tools in their AI-s5E model to support this: ChatGPT provided real-time translations of complex geometric terms (e.g., "prism," "cube") during vocabulary exploration, allowing students to focus on meaning rather than decoding [5]. This scaffolding ensured that cognitive resources were directed toward linguistic analysis (e.g., how "prism" is used in sentences), enhancing learning efficiency. Similarly, Behera et al. (2024) provided "grammar hunt" worksheets with pre-identified examples (e.g., "Find 3 sentences with reflexive pronouns"), guiding beginners to notice features they might otherwise miss [2].

Exploration's effectiveness also stems from its alignment with inquiry-based learning, which O'Malley and Chamot (1990) identify as a key strategy for L2 acquisition [10]. By allowing learners to "discover" language rules rather than receiving them passively, Exploration fosters deeper understanding and retention. Tarawneh (2024) found that ninth-graders who explored text structures independently (e.g., "How is this paragraph organized?") scored 20% higher on reading comprehension tests than those who were told the structure, as they developed transferable analytical skills [3].

3.3 Explanation

The Explanation phase transitions from exploration to formal instruction, where learners articulate their discoveries, and teachers provide explicit explanations to clarify linguistic rules or resolve misconceptions. This phase aligns with Ausubel's (1960) theory of meaningful learning, which emphasizes connecting new information to existing knowledge through organized explanations [19]. In L2 contexts, it helps learners move from implicit awareness to explicit understanding of rules [20].

Behera et al. (2024) employed a "planned-incidental" approach in this phase: after students explored grammar structures in texts (e.g., plural nouns in "Mongooses travel in groups"), the teacher formalized patterns into rules (e.g., "Regular plurals add -s, but 'mongoose ' becomes

‘mongooses’”) using examples from their discoveries [2]. This linkage between exploration and explanation ensured that rules were meaningful rather than arbitrary, enhancing retention by 35% compared to traditional lectures. For instance, when students struggled with reflexive pronouns, the teacher used their earlier discoveries (“themselves” in the text) to explain: “Reflexive pronouns show the action affects the subject-‘they hurt themselves ’ means they hurt their own bodies.”

Explanation is also critical for addressing fossilized errors by explicitly contrasting incorrect hypotheses with target norms [13]. Naguib (2019) found that secondary students who received explicit explanations of grammatical exceptions (e.g., “go-went” vs. overgeneralized “go-goed”) showed greater accuracy in writing (g=0.73) than those who relied solely on exploration [14]. The teacher in Naguib’s study used student errors as teachable moments: “You wrote ‘I go to the park yesterday’-let’s compare this to our exploration. What did we see in the story? ‘She went to the store’-‘go ’ changes to ‘went ’ for past actions.” By making new conceptions intelligible and plausible, Explanation paves the way for conceptual change.

Explanation also incorporates metalinguistic awareness, a key component of L2 learning [10]. Tarawneh (2024) trained teachers to use “language focus” moments during Explanation, where students labeled parts of speech in sentences they explored (e.g., “Underline the verb in ‘Budhu had gone’”) [3]. This metalinguistic discussion improved students ’ ability to identify grammatical errors in their writing by 27%, as they developed explicit vocabulary for talking about language.

3.4 Elaboration

Elaboration involves applying learned L2 concepts in new contexts (e.g., role-plays, extended writing), promoting transfer of knowledge to real-world use. This phase is rooted in theories of transfer [21], which suggest that multiple contextual applications enhance the ability to retrieve and adapt knowledge. In SLA, it helps proceduralize declarative knowledge (e.g., grammar rules) into automatic skills [22].

Yonan et al. (2022) demonstrated this in their study of transformational grammar: after learning passive voice rules during Explanation, students elaborated by converting active sentences from stories, news articles, and dialogues into passive forms (e.g., “The cat chased the mouse” → “The mouse was chased by the cat”) [23]. This varied practice helped them recognize that passive voice is used for emphasis or formality, not just rule application, leading to more flexible use. Post-tests showed a 40% improvement in passive voice accuracy compared to students who practiced only with textbook sentences.

Elaboration also strengthens vocabulary networks by requiring use in diverse contexts [24]. In Vafaeikia et al.’s (2023) online activities, students learned “ambiguous” during Exploration and then elaborated by using it in a sentence (“The ambiguous message confused us”), a dialogue (“A: What did she mean? B: It’s ambiguous”), and a reflection (“I struggled with the ambiguous instructions”) [4]. This multi-context application increased vocabulary retention by 30% compared to single-context practice.

Elaboration further enhances pragmatic competence by requiring adaptation to social contexts.

Tarawneh (2024) had ninth-graders rewrite dialogue from a formal story into informal slang (e.g., “Could you please pass the salt?” → “Pass the salt, pls?”), prompting them to notice register differences [3]. This practice helped learners apply grammatical knowledge while attending to sociolinguistic norms, a critical skill for real-world communication. Students in Tarawneh’s study reported a 25% increase in confidence when speaking with native English speakers, as they could adjust language to context.

3.5 Evaluation

Evaluation involves assessing understanding through formative/summative tasks (e.g., quizzes, self-assessments) and reflecting on learning processes. It leverages the “testing effect” [25], where retrieving information strengthens retention more than restudying. In L2 contexts, it encourages metacognition: learners identify gaps (e.g., difficulty with phrasal verbs) and adjust strategies [10].

Formative evaluation-such as peer feedback during role-plays-provides timely input to refine skills. Polanin et al.’s (2024) meta-analysis of 61 studies found that 5E implementations with integrated formative evaluation yielded larger effect sizes (g=0.82) than those with only summative assessment, as frequent retrieval practice reinforced learning [8]. In Vafaeikia et al.’s (2023) study, students used self-assessment checklists to rate their critical thinking (e.g., “I can identify the main idea”) and grammar use (e.g., “I used past tense correctly”) [4]. With 60.59% reporting improved ability to identify weaknesses, this metacognitive awareness empowered them to target revision (e.g., “I need to practice phrasal verbs”).

Summative evaluation, such as final exams, assesses overall proficiency but is less effective for retention alone. Behera et al. (2024) found that combining formative quizzes (with immediate feedback) and summative tests reduced grammar errors by 40% compared to summative-only assessment [2]. For example, after a formative quiz on prepositions, students received feedback

like, "'In Monday' should be 'On Monday'-check our exploration of time prepositions," allowing them to correct misconceptions before they fossilized.

Evaluation also includes teacher feedback that connects to prior phases, reinforcing the cyclical nature of the 5E model. Tarawneh (2024) trained teachers to provide feedback like, "You struggled with inference questions-remember our Exploration strategy: 'Look for clues in the last paragraph'" -linking evaluation back to earlier phases to strengthen strategy transfer [3]. This approach increased students ' ability to self-correct reading errors by 33%.

4. MODERATING FACTORS IN L2 CONTEXTS

4.1 Learner Proficiency

The 5E model's effectiveness varies with L2 proficiency, as learners ' linguistic schemas and processing capacities differ. Beginners benefit from structured Exploration (e.g., guided worksheets with fill-in-the-blank exercises) and explicit Explanation, as their limited L2 knowledge requires clear scaffolding [2]. In Behera's study of Odia-medium eighth-graders (A1 level), unguided text analysis led to confusion, but providing pre-identified grammar examples (e.g., "Find 2 sentences with 'has gone'") improved task completion by 50% [2]. These learners also required more repetition in Elaboration (e.g., practicing the same grammar rule in 3 contexts) to proceduralize knowledge.

Advanced learners, in contrast, thrive in open-ended Elaboration tasks (e.g., debating complex topics), as they can leverage existing knowledge for creative language use [4]. Iranian pre-IELTS students (B1 level) in Vafaeikia's study used Elaboration phases to experiment with nuanced vocabulary (e.g., "persuasive" vs. "convincing") and complex sentence structures (e.g., "Although climate change is urgent, many ignore it"), demonstrating flexible application of learned concepts [4]. This aligns with O'Malley and Chamot's (1990) observation that advanced learners use metacognitive strategies to adapt language to context, making open-ended tasks more effective than structured drills [10].

Proficiency also influences the type of cognitive load in Exploration. Beginners struggle with dual processing (e.g., decoding words and analyzing grammar simultaneously), so Gürefe et al. (2024) used AI tools to reduce load for A1 students (e.g., auto-translating difficult words), allowing them to focus on grammar [5]. Advanced learners, however, benefited from unassisted exploration, as dual processing strengthened their ability to integrate skills.

4.2 Technology Integration

Technology enhances 5E phases by reducing cognitive load and enabling personalized practice. Gürefe et al.'s (2024) AI-s5E model used tools like ChatGPT and DALL-3 to support Exploration: ChatGPT provided real-time translations of geometric terms (e.g., "prism" → "prizm" in Turkish), while DALL-3 generated visuals for stories created in Elaboration, making abstract concepts concrete [5]. These tools addressed individual needs: struggling learners received simplified explanations, while advanced learners accessed extended examples (e.g., "Show 5 sentences with 'prism'"). Post-tests showed that AI-supported 5E increased spatial language acquisition by 38% compared to traditional 5E.

Online platforms like Easyclass (Vafaeikia et al., 2023) facilitate collaborative Exploration by enabling asynchronous discussion, benefiting shy learners who hesitate to speak in class [4]. Iranian students posted annotations on texts (e.g., "This 'however ' shows contrast"), receiving peer feedback outside class hours, which extended exploration beyond traditional time limits. This asynchronous interaction increased participation among introverted students by 42%, as they could reflect before responding.

Technology also supports Evaluation through automated feedback and data tracking. Polanin et al. (2024) noted that 5E studies using online quizzes with immediate grammar feedback (e.g., "Incorrect: 'on ' is used for days") yielded higher retention than paper-based tests [8]. Behera et al. (2024) used spreadsheets to track which grammar rules students struggled with (e.g., 70% errors in reflexive pronouns), allowing targeted re-teaching in subsequent Elaboration phases [2].

4.3 Cultural Context

Cultural norms shape learner engagement with 5E phases, particularly collaborative Exploration.

In collectivist cultures like Jordan (Tarawneh, 2024), students readily participated in group tasks, with 80% reporting that "working with friends helps me understand better" [3]. This aligns with cultural values of cooperation, making collaborative Exploration more effective than individual work. Teachers in Tarawneh's study leveraged this by designing tasks like "Group story rewriting," where students negotiated language choices together [3].

In contexts emphasizing teacher authority (e.g., rural Odisha, India), learners initially resisted autonomous Exploration, expecting explicit instruction [2]. To address this, teachers gradually shifted from teacher-led to student-led exploration: first modeling strategies ("Let's find 3 past tense verbs together"), then assigning small group tasks, and finally independent work. This cultural adaptation increased student-led exploration participation from 30% to 75% over 6 weeks.

Cultural context also influences Elaboration tasks. In Turkish classrooms (Gürefe et al., 2024),

students engaged more with Elaboration tasks rooted in local contexts (e.g., "Describe your neighborhood using geometric terms") than global topics, as they could draw on familiar experiences [5]. This cultural relevance increased task completion by 25%, highlighting the need to adapt content to learners' cultural backgrounds.

5. CONCLUSION

The 5E Instructional Model's effectiveness in second language acquisition stems from its alignment with core cognitive principles across phases. Engagement activates prior knowledge and sparks motivation through cognitive conflict, leveraging learners ' existing schemas to prepare for new L2 input. Exploration promotes deep processing and collaborative inquiry, guided by scaffolding to focus attention on linguistic features. Explanation formalizes discoveries into meaningful rules, addressing misconceptions and facilitating conceptual change. Elaboration enables knowledge transfer and proceduralization, with multi-context practice strengthening retention and flexibility. Evaluation enhances retention through retrieval practice and metacognitive reflection, empowering learners to self-regulate.

Moderating factors-learner proficiency, technology, and culture-influence implementation but can be addressed through adaptive strategies: structured tasks for beginners, open-ended activities for advanced learners, AI tools to reduce load, and culturally responsive scaffolding. By grounding 5E implementation in these cognitive mechanisms, educators can foster meaningful L2 learning, equipping learners with linguistic competence and metacognitive skills for lifelong development.

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A Review of Focus-on-Form Instruction in Second Language Acquisition

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Abstract: Focus-on-form (FonF) instruction, which integrates attention to linguistic forms within meaningful communicative contexts, represents a significant pedagogical approach in second language acquisition (SLA). This review synthesizes theoretical foundations of FonF from cognitive, interactionist, and sociocultural perspectives, as well as empirical findings on its role in promoting grammatical, lexical, and pragmatic development-with specific emphasis on key moderating factors such as learner proficiency, linguistic complexity, and instructional context. For instance, empirical studies indicate that FonF is particularly effective for acquiring complex syntactic structures (e.g., English passive voice), and prompts (encouraging self-repair) outperform recasts in long-term retention of target forms. Current debates regarding implicit versus explicit FonF, optimal timing of instruction, and ecological validity of laboratory-based findings are also discussed. The review concludes by identifying future research directions: conducting longitudinal studies to examine long-term effects and transferability of FonF, integrating individual differences (e.g., working memory) to develop personalized instruction via adaptive technologies, and exploring FonF adaptation in digital (e.g., VR-based platforms) and multilingual contexts (e.g., content-based immersion programs). This synthesis clarifies the interactive relationships between FonF components and provides targeted guidance for subsequent empirical and pedagogical practices.

Keywords: Focus-on-Form; Second Language Acquisition; Corrective Feedback; Communicative Language Teaching; Pedagogical Adaptation; Digital Language Learning

1. INTRODUCTION

The integration of form and meaning in second language acquisition (SLA) has constituted a fundamental concern in language pedagogy and research. Traditional methods such as grammar-translation and audio-lingual approaches emphasized the explicit teaching of grammatical rules and structures, often at the expense of communicative practice. With the advent of communicative language teaching (CLT) in the 1970s and 1980s, the pendulum swung toward meaning-centered instruction, prioritizing fluency and communicative competence over accuracy[1]. However, empirical evidence soon revealed that an exclusive focus on meaning could lead to persistent grammatical inaccuracies and fossilization[2]. This realization catalyzed the development of focus on form (FonF) instruction-an approach that strategically integrates attention to linguistic forms within meaningful communicative contexts[3]. First formally proposed by Michael Long[3], FonF distinguishes itself from traditional "focus on forms" (FonFs) by addressing linguistic elements only as they arise incidentally during communication. Over the past three decades, FonF has evolved into a robust framework supported by cognitive, interactionist, and pedagogical research. This review synthesizes theoretical foundations, empirical findings, and methodological issues in FonF research, highlighting its contributions to SLA and identifying avenues for future inquiry. The discussion incorporates insights from key studies by Schmidt[4], Doughty and Williams[5], Ellis[6], Spada[7], and others.

2. THEORETICAL FOUNDATIONS OF FOCUS ON FORM INSTRUCTION

2.1 The Noticing Hypothesis

Central to FonF is Schmidt's[4] noticing hypothesis, which posits that conscious attention to linguistic forms is a prerequisite for their acquisition. Schmidt distinguishes between "noticing" (conscious registration of forms) and "understanding" (recognition of underlying rules). In FonF, techniques such as input enhancement, corrective feedback, and metalinguistic cues are employed to promote noticing. For example, textual enhancement (e.g., bolding or italicizing target forms in reading passages) can increase the perceptual salience of grammatical structures, facilitating their intake[8]. Similarly, during communicative tasks, teachers may draw learners' attention to form-meaning connections, thereby promoting "noticing the gap" between their interlanguage and the target language[9].

2.2 The Interaction Hypothesis

Long's[10] interaction hypothesis provides further theoretical support for FonF. It contends that negotiated interaction-where learners engage in clarification requests, comprehension checks, and recasts-facilitates acquisition by connecting input, attention, and output. During meaning-focused activities, communication breakdowns often trigger attention to form, creating opportunities for learning. For instance, if a learner produces an utterance such as "Yesterday I went to school," an interlocutor might

respond with a recast: "Oh, you went to school?" Such implicit feedback encourages the learner to notice the past tense form without interrupting communication[11]. Research in both classroom and laboratory settings has demonstrated that interactional modifications promote the acquisition of various linguistic features, including question formation, tense-aspect morphology, and lexical items[12].

2.3 Cognitive-Processing Perspectives

Cognitive theories, particularly VanPatten's[13] input processing theory, emphasize the limited capacity of learners' attentional resources. VanPatten argues that learners prioritize meaning over form during comprehension, leading to incomplete processing of grammatical elements. FonF instruction addresses this by directing learners' attention to critical form-meaning mappings. For example, processing instruction activities encourage learners to rely on morphological cues rather than lexical or word-order cues to interpret sentences. Studies have shown that such interventions improve learners' interpretation and production of target structures[14][15]. Skill acquisition theory[16] further suggests that FonF supports the transition from declarative knowledge to proceduralized, automatized use through practice in communicative contexts.

2.4 Sociocultural Theory

Vygotsky's sociocultural theory offers another valuable perspective on FonF instruction. This theory emphasizes that learning occurs through social interaction and mediated assistance from more knowledgeable others[17]. In FonF, teachers or peers can provide scaffolded support that is gradually withdrawn as learners develop greater control over linguistic forms. For example, during a collaborative writing task, peers might collectively focus on grammatical accuracy, providing each other with corrective feedback and explanations. This collaborative dialogue creates opportunities for language development through mediated interaction[18]. Research from a sociocultural perspective has shown that such collaborative FonF activities can promote both linguistic accuracy and metacognitive awareness[19].

3. EMPIRICAL RESEARCH ON FOCUS ON FORM INSTRUCTION

3.1 Grammatical Development

A substantial body of research supports the efficacy of FonF in promoting grammatical accuracy. In a seminal classroom study, Doughty and Varela[20] examined the effects of corrective feedback (recasts and prompts) on English past tense forms among middle school ESL learners. The experimental group received FonF during science report tasks, while the control group participated in meaning-only activities. Results showed significant gains in accuracy for the FonF group, both immediately and in delayed posttests. Similarly, Williams[21] found that reactive FonF during communicative tasks enhanced learners' acquisition of French conditional forms. Meta-analyses by Norris and Ortega[22] and Spada and Tomita[23] confirm that form-focused instruction, particularly when integrated into communicative contexts, has durable, medium-to-large effects on grammatical learning.

More recent research has investigated the effects of FonF on complex syntactic structures. Yang and Lyster[24] examined how different types of corrective feedback affected Chinese EFL learners' acquisition of passive constructions. Their findings indicated that prompts (which encourage self-repair) were more effective than recasts for long-term retention of passive forms. Similarly, a study by Nassaji[25] demonstrated that FonF interventions incorporating meta-linguistic explanations were particularly effective for helping learners acquire English phrasal verbs. These studies collectively suggest that the effectiveness of FonF for grammar learning may depend on both the type of linguistic structure and the nature of the instructional intervention.

3.2 Lexical and Pragmatic Development

FonF also benefits vocabulary and pragmatic development. Ellis[6] demonstrated that drawing learners' attention to lexical items during meaning-focused activities-through techniques such as negotiation, input enhancement, or vocabulary elaboration-enhances retention and depth of word knowledge. For example, in a task requiring information exchange, learners who negotiated the meaning of unknown words showed better recall than those who received pre-taught word lists[26]. In pragmatics, FonF interventions targeting speech acts (e.g., requests, apologies) through explicit discussion and feedback have proven effective in raising learners' pragmatic awareness and production[27]. Takimoto[28] found that structured input tasks with explicit metapragmatic information improved learners' ability to produce appropriate polite expressions.

Research by Boers and his colleagues[29] has further demonstrated how FonF techniques can enhance phraseological competence-the ability to use formulaic sequences appropriately. Their studies show that techniques such as typographical enhancement, verbal emphasis, and task design that requires the use of specific multi-word expressions can significantly improve learners' acquisition of collocations and idioms. Similarly, research on pragmatic development has expanded to examine how FonF can address sociopragmatic appropriateness-the ability to use language forms in socially appropriate ways. Taguchi[30] found that a combination of explicit instruction and metapragmatic discussion significantly improved learners' ability to produce appropriate refusals and requests in various social contexts.

3.3 Moderating Factors

The effectiveness of FonF is influenced by several

factors, including linguistic target, learner proficiency, and instructional context. Complex, low-salience forms (e.g., English articles) may require more explicit and frequent attention than simpler, perceptually salient forms[7]. Proficiency also plays a role: beginner learners may benefit from more explicit FonF, while advanced learners can often learn from implicit feedback[31]. Classroom context matters as well; in foreign language settings with limited input, FonF may be particularly crucial for developing accuracy[32]. Individual differences such as working memory capacity, analytic ability, and motivation further moderate FonF effectiveness[33].

Recent research has begun to explore how cognitive individual differences interact with different types of FonF. Goo[34] found that working memory capacity significantly moderated learners' ability to benefit from recasts, with higher working memory capacity learners showing greater gains. Similarly, research by Granena[35] demonstrated that learners' cognitive aptitudes, particularly grammatical sensitivity and memory capacity, influenced their responses to different types of FonF interventions. These findings suggest that optimal FonF implementation may need to be tailored to individual learner characteristics, though more research is needed to develop practical applications of this knowledge.

4. CURRENT DEBATES AND PEDAGOGICAL IMPLICATIONS

4.1 Implicit vs. Explicit FonF

A key debate concerns the relative effectiveness of implicit versus explicit FonF. Implicit techniques (e.g., recasts, input flood) maintain communicative flow but may be less noticeable, especially for low-proficiency learners. Explicit techniques (e.g., metalinguistic explanation, overt correction) are more salient but risk disrupting communication and raising affective filters[36]. Research suggests that the choice depends on multiple factors, including the linguistic feature, learner characteristics, and task demands. For instance, recasts may be effective for phonological and morphological errors, whereas explicit feedback may be needed for syntactic and pragmatic errors[37]. A balanced approach that combines implicit and explicit strategies tailored to context is likely optimal[7].

The implicit-explicit debate has expanded to consider neurological correlates of different learning processes. Morgan-Short and colleagues[38] used EEG to examine brain responses to implicit and explicit learning conditions, finding that while both types led to similar behavioral outcomes, they engaged different neural pathways. This neurological evidence suggests that implicit and explicit FonF may represent fundamentally different learning processes, with implications for long-term retention and transfer of learning. Pedagogically, this research supports a complementary approach that strategically employs both implicit and explicit techniques based on learning goals and contexts.

4.2 Timing and Implementation

The optimal timing of FonF-whether pre-emptive, reactive, or post-task-remains contested. Integrated FonF during tasks may enhance relevance and immediacy, but isolated FonF before or after tasks may allow for more systematic explanation and practice[39]. Task design also influences FonF efficacy; tasks that require the use of specific structures (e.g., narrative tasks for past tense) can create natural opportunities for form-focused interaction[40]. Technological tools, such as computer-mediated communication platforms, offer new possibilities for delivering timely and individualized FonF[41].

Recent research has begun to explore more nuanced approaches to timing. Bryfonski and Ma[42] proposed a "cyclical focus on form" approach that alternates between periods of focused attention to form and meaning throughout a task or lesson sequence. Their research suggests that this cyclical approach may be more effective than either isolated or integrated approaches alone, as it allows for both immediate feedback during communication and more reflective consideration of forms after tasks. Additionally, research on computer-mediated communication has shown that technology can provide unique opportunities for FonF, such as through delayed feedback in asynchronous interactions or automated feedback in intelligent tutoring systems[43].

4.3 Contextual and Ecological Validity

A growing area of debate concerns the ecological validity of FonF research. Many studies occur in controlled laboratory settings or intensive language programs, raising questions about the applicability of findings to diverse educational contexts[44]. Researchers have called for more classroom-based research that examines how FonF operates in authentic educational settings with various constraints, including large class sizes, limited resources, and diverse learner populations[45].

This has led to increased interest in teacher cognition and implementation of FonF. Research has shown that teachers' beliefs about language learning and practical knowledge significantly influence how they implement FonF in their classrooms[46]. Studies exploring teacher-student interactions in diverse contexts have revealed that effective FonF implementation requires not only linguistic knowledge but also pedagogical skill and intercultural awareness[47]. These findings highlight the need for professional development that helps teachers adapt FonF principles to their specific teaching contexts.

5. FUTURE DIRECTIONS

To advance the theoretical depth and practical applicability of focus-on-form (FonF) instruction in second language acquisition (SLA), future research should prioritize three interrelated dimensions:

addressing gaps in long-term learning outcomes, accounting for learner heterogeneity, and adapting to evolving learning contexts.

First, research must extend beyond short-term learning gains to examine the long-term effects and transferability of FonF. While existing studies consistently document immediate improvements in grammatical, lexical, and pragmatic competence through FonF, there is a dearth of longitudinal investigations tracking how these gains persist over time (e.g., 6–12 months post-instruction) and whether learned linguistic forms can be transferred to novel communicative contexts (e.g., academic writing, informal dialogue). Longitudinal designs that incorporate delayed post-tests and varied task types (e.g., from controlled exercises to authentic interactions) would elucidate the durability of FonF effects and the mechanisms of interlanguage restructuring-such as whether frequent, contextually embedded FonF reduces fossilization risk for complex forms like English articles or phrasal verbs[48].

Second, future work should integrate individual differences into FonF research to develop personalized instructional approaches. Current findings largely treat learners as a homogeneous group, yet factors like cognitive styles (e.g., analytic vs. holistic processing), affective traits (e.g., anxiety, motivation), and cognitive aptitudes (e.g., working memory capacity, grammatical sensitivity) significantly moderate learning outcomes. For example, learners with higher working memory may benefit more from implicit FonF techniques like recasts, while those with lower analytic ability may require explicit metalinguistic explanations. Leveraging advances in adaptive learning technologies-such as AI-driven platforms that adjust feedback type or FonF timing based on real-time learner performance-could bridge this gap, enabling instruction that responds to individual needs and preferences[49].

Third, research needs to explore FonF adaptation in multilingual and digital environments, where modern language learning increasingly occurs. In multilingual settings (e.g., content-based instruction, immersion programs), questions remain about how FonF can be aligned with content learning goals (e.g., teaching scientific vocabulary collocations alongside biology concepts) and how cross-linguistic transfer (e.g., from L1 to L2 collocational patterns) interacts with FonF effects. Meanwhile, digital tools-including computer-mediated communication (CMC) platforms, mobile apps, and virtual reality (VR) environments-offer new avenues for delivering FonF: for instance, CMC can provide asynchronous corrective feedback, while VR can simulate real-world contexts (e.g., workplace interactions) to embed FonF in authentic scenarios[50]. Investigating these contexts would clarify how technological and multilingual affordances can enhance FonF's ecological validity and reach.

6. CONCLUSION

Focus on form instruction represents a principled and empirically supported approach to integrating grammar and communication in second language teaching. Grounded in cognitive and interactionist theories, FonF enhances learners' awareness of form-function relationships and promotes accuracy within meaningful language use. Ongoing debates regarding implicit/explicit balance, timing, and contextual adaptation reflect the dynamic and evolving nature of FonF research. Future investigations into long-term effects, individual differences, and technological applications will further refine our understanding and implementation of FonF, contributing to more effective and responsive language pedagogy.

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Applications of AI Models in Student Education

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Abstract: With the rapid development of artificial intelligence (AI) technology, the application of AI models in the field of education is becoming increasingly widespread. This paper aims to explore the current status, advantages, challenges, and future development directions of AI models in student education. Through case studies, this paper evaluates the practical effects of AI models in student education and proposes corresponding suggestions and improvement measures to provide references for the innovative development of student education.

Keywords: AI Models; Student Education; Application; Effect Evaluation

In the digital age, artificial intelligence (AI) technology is profoundly changing various industries, and the field of education is no exception. Student education plays a crucial role in the construction of students' knowledge systems and the cultivation of their learning abilities. Introducing AI models into student education can not only provide teaching assistance for teachers but also create a more personalized and efficient learning experience for students. This paper will discuss the current status, advantages, challenges, and future development directions of AI models in student education and analyze their practical effects through case studies.

1. THE APPLICATION HISTORY OF AI TECHNOLOGY IN EDUCATION

1.1 Early Applications (1960s - Early 2010s)

The early applications of AI technology in education can be traced back to the 1960s, with the development of the PLATO system at the University of Illinois at Urbana-Champaign. This intelligent teaching system allowed students to interact with educational materials through a graphical user interface. Since then, AI has been closely linked with the field of education. Notable AI researchers such as Michie and Howe continued to explore educational technology research throughout their careers and published a paper in 1989 advocating the creation of teaching machines through machine learning[1].

1.2 Rapid Development Period (Early 2010s - Early 2020s)

With the development of big data, cloud computing, the Internet, and the Internet of Things, ubiquitous sensing data and graphical processing units have propelled the rapid development of AI technology, particularly deep neural networks. This progress has significantly bridged the gap between scientific research and practical applications. For example, in 2012, Hinton and his student Alex Krizhevsky designed the AlexNet neural network model, which achieved a groundbreaking victory in the ImageNet competition[2]. This marked the first time a model performed exceptionally well on the ImageNet dataset, sparking a surge in research on neural networks.

1.3 The Era of Large Models (Early 2020s - Present)

In 2023, several domestic enterprises and institutions in China successively released large language models and made them available to the public, marking a significant leap in the field of artificial intelligence. These large language models, with their capabilities in language understanding, logical reasoning, knowledge Q&A, and text generation, have created a sensation in the education sector. For example, OpenAI's GPT-3, a natural language deep learning model with 175 billion parameters, is 100 times larger than its predecessor, GPT-2. Trained on nearly 0.5 trillion words, GPT-3 achieves state-of-the-art performance on multiple NLP tasks, including question answering, translation, and article writing[3].

2. THE CURRENT STATUS OF AI MODELS IN STUDENT EDUCATION

2.1 Current Application Status

AI technology has been applied across the entire chain of education, including teaching, learning, examination, evaluation, and management, accelerating the implementation of new education models, services, and

business forms. These applications cater to educational institutions, teachers, and students, offering functions such as personalized class formation, intelligent teaching plans, and smart homework assistance. Reports indicate that the global AI education market is growing rapidly, with the Asia-Pacific region experiencing the fastest development. In China, significant progress has been made in the application of AI technology in education. For example, in 2024, Beijing's physical education middle school exam expanded from "8 out of 3" to "22 out of 4," with 14 new sports items requiring precise motion capture and data-based analysis and assessment. AI vision technology can fully meet these needs. The Grinvin Deep Vision Sports Training and Examination System was successfully implemented in multiple districts of Beijing for the physical education middle school exam, covering nearly 10 examination sites and tens of thousands of candidates. The use of AI vision technology throughout the process resulted in improved assessment efficiency, increased recognition accuracy, and enhanced fairness[4].

2.2 Personalized Learning

AI models can tailor learning plans and exercises for each student based on their learning progress, knowledge mastery, and learning style. For example, the Jiu Zhang large model from Xueersi provides step-by-step problem-solving guidance through photo-based inquiries and intelligent tutoring, preventing students from directly copying answers and fostering critical thinking. Pilot applications in Henan Data Group and Beijing Hongzhi Middle School have shown that Jiu Zhang's inquiry method, inspired by Socratic questioning, guides students to think deeply and internalize knowledge. Additionally, the embedded psychological counseling large model offers emotional support and psychological guidance to alleviate learning stress[5].

2.3 Language Learning

AI models are widely used in language learning. For example, intelligent oral assessment systems have been involved in the grading of English speaking and listening exams in multiple provinces and cities, addressing the challenges of organizing traditional language exams and the subjectivity of human grading. The Chinese and English essay review function, based on OCR, data annotation, language model pre-training, and large language models, offers basic features such as text and idiom error detection, spelling correction, and vocabulary usage tips. Advanced features include semantic understanding, structural evaluation, and recommendations for exemplary essays.

2.4 Science and Experimental Teaching

AI models can create virtual science laboratory environments where students can perform various experimental operations on computers or tablets. For example, Ma Tao, chief expert of the Educational Technology Committee of the Hubei Provincial Teachers' Education Society, mentioned in his report that AI models provide rich teaching resources and auxiliary tools for educators, significantly enhancing the efficiency of lesson preparation and teaching while offering personalized learning support for students. In a science course on "Investigating the Characteristics of Magnetic Poles," AI tools enable real-time analysis and dynamic presentation of experimental data, helping teachers accurately grasp student learning situations.

2.5 Classroom Management and Teaching Assistance

AI models can also be used for classroom management, such as attendance and roll call. Utilizing AI's facial recognition technology, quick and accurate attendance can be achieved, saving class time and improving teaching efficiency. For example, in Xiangyang City's Fancheng District, Changzheng Road Primary School leverages AI technology to support the entire teaching process. During collective lesson preparation, AI integrates high-quality teaching resources to generate dynamic lesson plans and automatically creates tiered exercise libraries, reducing teachers' repetitive tasks. In the classroom, AI-generated animations immerse students in the learning experience. During essay review, AI instantly generates comments and suggestions. In math classes, AI systems analyze real-time answer data and push tiered practice exercises. Post-class, the learning situation analysis platform automatically generates reports to help teachers adjust their teaching strategies. As a result, student classroom participation has increased by 35%, and teacher lesson preparation efficiency has doubled.

2.6 Growth Trends

With the continuous development and in-depth application of AI technology, the field of education is on the brink of a new round of intelligent transformation. In the future, the development of AI in education will focus more on personalization, intelligence, and

fairness, while driving innovation in educational methods and improving teaching quality. For example, future AI technology will further enhance the personalization of learning, enabling each student to obtain a customized learning path. Through big data analysis and deep learning technology, AI will accurately identify students' knowledge levels, learning habits, and interests, and dynamically adjust teaching content and strategies in real-time.

3. THE ADVANTAGES OF AI MODELS IN STUDENT EDUCATION

3.1 Personalized Learning Experience

AI models can provide personalized learning content and exercises based on each student's learning progress and style, helping students better grasp knowledge and improve learning efficiency. AI technology creates a more personalized and efficient learning experience for students. For example, intelligent teaching systems and intelligent assessment are typical applications. Intelligent teaching systems are adaptive learning systems that achieve intelligent teaching through data transmission with different models and knowledge bases, voice recognition technology for data reception, and enhanced machine learning capabilities. Intelligent assessment leverages image recognition and voice recognition technologies to automate and 智能化 teaching assessment activities.

3.2 Enhancing Educational Equity

By analyzing factors such as students' family backgrounds, geographical locations, and subject abilities, AI can predict which students require additional support and provide information to schools and teachers to ensure that every student receives a fair educational opportunity. AI technology can be applied throughout the education industry to achieve personalized education. The comprehensive use of various technologies such as computer vision and voice interaction in educational scenarios can address the uneven distribution of educational resources, enhance learning interest, improve teaching effectiveness and learning efficiency, and help educational institutions enhance their research and development progress and the intelligent level of campus management and operation. With the assistance of AI technology, China's digital education sector has grown rapidly. The Global Digital Education Development Index released by the Chinese Academy of Educational Sciences shows that China's ranking has jumped from 24th to 9th in just three years.

3.3 Enhancing Teaching Efficiency

AI technology can automate repetitive teaching tasks, such as grading assignments and taking attendance, thereby saving teachers' time and energy and allowing them to focus more on innovating teaching content and providing personalized guidance to students. AI technology supports personalized learning by analyzing learning data, offering customized learning paths and resources to meet individual students' needs. Meanwhile, AI technology also assists teachers in using intelligent teaching systems and virtual assistants for teaching design, classroom management, and student tutoring, reducing their workload and improving teaching efficiency. In addition, the application of AI in educational assessment, such as automatic grading and intelligent analysis, can provide a more objective and comprehensive evaluation of students' learning and offer scientific basis for educational decision-making.

Application Differences of AI Models in Different Educational Stages

4.1 Primary School Stage

In primary schools, the application of AI models mainly focuses on personalized learning and teaching assistance. For example, a primary school plans to design a project-based learning (PBL) unit around the theme of "local river pollution," integrating local history, environmental science, and expository writing. The teaching team can use AI tools to conceptualize and design the project framework. AI can suggest the division of project phases, essential driving questions, possible inquiry activities, and preliminary assessment rubric recommendations. Additionally, AI can help design tasks that integrate scientific knowledge, technological tools, and teamwork skills[6].

4.2 Middle School Stage

In middle schools, the application of AI models is more diverse, including personalized learning, language learning, and science and experimental teaching. For instance, a middle school science teacher can use AI tools to plan a unit on "ecosystems" for a class with students of different learning needs. Based on the input of the unit theme, grade level, learning objectives, and basic characteristics of the student group, AI can generate a basic lesson plan framework with suggestions for differentiated activities. Moreover, AI can be used in intelligent oral assessment systems to grade spoken English tests in multiple provinces and cities.

4.3 University Stage

In universities, the

application of AI models mainly focuses on teaching design generation and precision teaching. For example, Huazhong Normal University's "Xiao Ya" platform is a self-developed cloud-based integrated intelligent education SPOC platform. It has built a hybrid teaching and learning environment composed of modules such as course knowledge graphs, intelligent Q&A, and intelligent recommendations. It has also formed a data-driven service system for preparation, teaching, learning, testing, evaluation, supervision, and management. This system has achieved the concretization of teaching theories, standardization of teaching design, dataization of teaching behaviors, and precision of teacher evaluation.

The Impact of AI Models on Educational Models and Teaching Methods 5.1 Transformation of Educational Models The application of AI models has driven the shift of educational models from the traditional one-size-fits-all model to a personalized and intelligent one. With AI technology, teachers can provide personalized learning content and exercises according to each student's learning progress and style, helping students better grasp knowledge and improve learning efficiency. For example, AI-assisted teaching design enables teachers to use AI tools to generate differentiated teaching plans, design cross-disciplinary project-based learning (PBL) outlines, create inquiry-based questions and prompts, develop adaptive learning activity sequences, and conceive innovative assessment ideas.

5.2 Innovation of Teaching Methods The application of AI models has also spurred continuous innovation in teaching methods. For example, AI tools can enable real-time analysis and dynamic presentation of experimental data, helping teachers accurately grasp the learning situation. In terms of teaching methods, AI models offer innovative applications such as the spatiotemporal connection method, human-computer debate method, writing optimization method, and on-site generation method. These methods not only break the spatiotemporal limitations of traditional teaching but also stimulate students' thinking vitality and creative inspiration, making classroom teaching more vivid and efficient. In addition, AI models can provide students with a more personalized and efficient learning experience through intelligent teaching systems and intelligent assessments.

From the above analysis, it can be seen that the application of AI models in education has not only improved educational quality, students' learning experience, and educational equity but also promoted the innovation and development of educational models and teaching methods.

6. PRACTICAL CASES OF AI MODELS IN STUDENT EDUCATION

Intelligent Tutoring and Learning Resource Recommendation In mathematics teaching for students, AI models can assess students' learning progress and understanding in real-time and generate personalized tutoring plans based on their performance. For example, in a mathematics class where an AI-assisted teaching system was introduced, the results showed that the class using the AI system achieved an average increase of more than 15% in mathematics scores in the final exam compared to traditional classes.

Classroom Interaction and Teaching Decision Support AI models provide real-time decision support for teachers, enabling them to obtain each student's learning status, interactive performance, and depth of understanding of teaching content in real-time, thereby making precise teaching decisions. For example, in a Chinese language class at Jiangjia Garden Branch of Fangcaoyuan School in Nanjing, the teacher guided students to use AI to search for and filter information and create tour guide scripts based on mind maps. The AI agent provided real-time evaluation and feedback, training students' oral skills.

Interdisciplinary Integration and Innovative Teaching Models AI technology has also promoted the exploration of interdisciplinary integration and innovative teaching models in student education. For example, some students in Nanjing have integrated AI with labor education, using innovative scenarios such as intelligent material library management and labor process data analysis to enable students to learn and apply AI technology in practice.

Challenges in the Application of AI Models in Student Education

Data Privacy and Security Issues When applying AI models, it is necessary to collect and process a large amount of student data, which involves issues of student privacy and data security. Ensuring the security and privacy of student information is a prerequisite for the application of AI technology.

Teacher Training and Technical Application Capabilities Teachers' familiarity and

application capabilities with AI technology directly affect the effectiveness of AI models in teaching. Therefore, it is necessary to strengthen teacher training and improve their understanding and application capabilities of AI technology.

Technical Costs and Resource Investment The development and application of AI models require certain technical costs and resource investment. For some regions and schools with poor economic conditions, it may be difficult to bear these costs, thereby limiting the widespread application of AI technology in student education.

Conclusions and Outlook The application of AI models in student education has significant advantages and broad development prospects. Through applications such as personalized learning, improving educational equity, and enhancing teaching efficiency, AI technology has brought new opportunities and changes to student education. However, we also need to face the challenges encountered in the application process, such as data privacy and security, teacher training, and technical costs. In the future, with the continuous progress of technology and the updating of educational concepts, we have reason to believe that AI models will play a more important role in student education and create a higher-quality and more efficient learning environment for students.

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Practical Research on the Teaching Reform of the Course "Application of Sensor and Intelligent Detection Technology" Based on "Dual-Chain Driven and Integration of Posts, Courses, Competitions and Certificates"

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Abstract:In higher education, Application of Sensor and Intelligent Detection Technology is key for technical talent cultivation, with its quality affecting students' competitiveness and industrial talent supply. Yet traditional teaching (disjointed theory-practice, outdated resources, insufficient ideological education) fails to meet industrial needs.

Keywords: APractical Research,Application of Sensor,Dual-Chain Driven

1. RESEARCH PURPOSE AND SIGNIFICANCE

In response, Zibo Vocational and Technical University's School of Intelligent Manufacturing, with Shandong Rhine Koster Intelligent Technology Co., Ltd., reformed the course's hybrid model around "dual-chain driven integration of positions, courses, competitions, certificates". It links education-industrial chains and talent-innovation chains, integrating job demands, teaching, competitions, and certificates for systematic reform.

This study sorts the reform's background, strategies, and effectiveness to offer a replicable paradigm for higher education technical course reform and promote education-industry integration.

Keywords: Sensor; Intelligent detection ; Hybrid teaching model

Amid the deepening global sci-tech revolution and industrial transformation, sensor technology — a core of modern information technology — enables strategic emerging industries (e.g., intelligent manufacturing, smart healthcare) and drives industrial intelligent transformation via applications in industrial automation and IoT.[1]

1.1 Research Purpose

This study aims to address the prominent issues in the traditional teaching of the course. By constructing a three-dimensional teaching system featuring "technology empowerment + industry-education collaboration + ideological and political integration", it seeks to achieve "three transformations": transforming from a theory-dominated teaching model to one that deeply integrates theory and practice; transforming from reliance on single teaching resources to the establishment of a ubiquitous learning resource system; and transforming from mere skill instruction to the cultivation of "integrated moral and technical literacy". Ultimately, it intends to enhance students' professional core competencies and vocational literacy, laying a solid foundation for their future career development.[2]

1.2 Research Significance

Theoretically, this study can enrich the theory of hybrid teaching models for technical courses in colleges and universities, explore the implementation path of "integration of positions, courses, competitions, and certificates", and provide a new perspective for the reform of vocational education. Practically, it will form a replicable course teaching model to offer reference for the reform of similar courses in other colleges and universities. Meanwhile, through industry-education collaboration, it will realize the accurate connection between education and industry, improve the effectiveness of talent cultivation, and promote positive interaction between vocational education and industrial development.

1.3 Research Methods

Case Study Method: Taking the curriculum reform of "Application of Sensor and Intelligent Detection Technology"as a specific case, this method systematically analyzes the reform background, implementation process and effects, and extracts reform experiences.

Action Research Method: In the process of reform implementation, through the cycle of "planning - implementation - observation - reflection", this method continuously optimizes teaching strategies and resource allocation to ensure the achievement of reform goals.

Data Analysis Method: This method collects quantitative data such as students' classroom participation, passing rate of practical operation assessment and interaction volume of online platforms, and combines qualitative materials such as

student interviews and enterprise feedback to objectively evaluate the reform effects.

2. PAIN POINTS IN CURRICULUM TEACHING REFORM

2.1 Disconnection between Theory and Practice, and Weak Engineering Application Abilities of Students

Traditional teaching is dominated by theoretical lectures. In the teaching of sensor principles, structures and characteristics, although the explanations are detailed and in-depth, there is a severe disconnection from actual application scenarios. This makes students' understanding of knowledge abstract and difficult to remember. Practical training courses are usually arranged after theoretical learning, and most of them are confirmatory experiments. Students only need to operate according to established procedures, lacking opportunities for active thinking and innovative practice.[3]

2.2 Outdated and Dispersed Teaching Resources, Hindering Students' Independent Learning

Traditional teaching resources are mainly limited to textbooks and a small number of courseware. The content update cycle of textbooks is long, which fails to timely cover cutting-edge technologies and application cases such as optical fiber sensors and MEMS sensors. If students want to acquire cutting-edge knowledge, they need to spend a lot of time and energy screening resources in libraries or on the Internet, and the quality of the obtained resources varies. At the same time, online resources and offline teaching lack organic integration and have not formed a unified learning system, making it difficult for students to achieve efficient integration and utilization of teaching resources, which seriously restricts the efficiency of their independent learning.

3. IMPLEMENTATION STRATEGIES OF TEACHING REFORM BASED ON "DUAL-CHAIN DRIVEN AND INTEGRATION OF POSTS, COURSES, COMPETITIONS AND CERTIFICATES"

3.1 Intelligent or Code Matrix: Building a Resource Network of "Scan and Learn"

To effectively address the problems of scattered teaching resources and inconvenient access, the project team has carried out innovative transformation of the course textbooks, and arranged an intelligent QR code matrix at the footer of each chapter. By scanning the QR codes, students can directly jump to the customized online course platform to access the four-in-one learning resources consisting of "micro-course videos + virtual simulation + case library + exercise set".

Micro-course videos: Recorded by professional teachers, each video lasts 5-8 minutes and focuses on core knowledge points such as sensor principles, installation and commissioning. It breaks down difficult points through animation demonstrations, practical operation explanations and other forms, helping students quickly master key content.

Virtual simulation module: Relying on industrial-grade virtual simulation technology, it reproduces the installation and commissioning scenarios of temperature sensors and photoelectric sensors in intelligent production lines. Students can adjust parameters to observe signal changes in real time, practice operational skills repeatedly in a safe and low-cost environment, and avoid the risk of damage to training equipment.

Case library: It collects sensor application cases in fields such as industry, medical care and transportation, including problem descriptions, solutions and effect evaluations, helping students establish a "theory-practice" associative cognition.

Exercise set: Hierarchical exercises are designed for the knowledge points of each chapter, ranging from basic consolidation to extended application, so as to meet the needs of students with different learning abilities.

3.2 OMO Learning Closed Loop: Realizing the Whole-Process Connection of "Before Class - During Class - After Class"

To break the barrier between theory and practice, an OMO (Online-Merge-Offline) learning closed loop of "pre-class preview - in-class practical operation - post-class review" has been constructed, realizing the in-depth integration of online learning and offline teaching. In addition, teachers and students, as well as among students, can conduct in-depth exchanges around practical problems through platform messages, live seminars and other forms, forming a good learning ecology of knowledge co-construction and sharing.

3.3 Industry-education Collaborative Content Design to Align with Core Job Requirements

In-depth cooperation has been carried out with Shandong Rhine Kost Intelligent Technology Co., Ltd. Around the core business scenarios of the enterprise, such as intelligent production line operation and maintenance, and industrial automation testing, a practical teaching module titled "Sensor Selection and Fault Troubleshooting" has been jointly developed. The specific implementation process is as follows:

Case Extraction: Enterprise engineers sort out typical cases from actual services, such as "dust interference of photoelectric sensors in manufacturing production lines" and "installation errors of proximity sensors in warehousing and logistics equipment". They clarify the fault phenomena, core difficulties and solutions in the cases.

Task Transformation: The teaching team transforms the cases into a four-stage progressive teaching task of "fault phenomenon identification - cause analysis - tool application - fault repair". It is matched with core knowledge points such as sensor threshold setting, installation specifications and signal analysis to ensure that the task difficulty is compatible with students' cognitive level.

Scenario Simulation: Enterprise scenarios are reproduced in practical training classes, allowing students to participate in fault troubleshooting as "engineers". Through team collaboration to complete tasks, students systematically master the sensor application and fault handling skills required for the job.

4. IMPLEMENTATION EFFECTS OF TEACHING REFORM

4.1 Enhanced Classroom Participation and Learning Initiative

After the implementation of the teaching reform, students' learning attitude has shifted from passive listening in the past to active participation in classroom learning. Their enthusiasm for participating in learning activities such as classroom questioning, group discussions, and practical operations has been greatly enhanced. Statistical data shows that students' classroom participation has increased by 30% compared with that before the reform, and the average weekly active learning time on the online platform has increased by 1.5 hours. Students' learning initiative and independent learning ability have been significantly strengthened.

4.2 Improvement in Professional Skills and Engineering Application Abilities

In the sensor practical operation assessment, the reform has achieved remarkable results. Students can not only skillfully complete basic tasks such as sensor installation and debugging, but also have the ability to independently design sensor application schemes for multiple scenarios and solve complex fault problems.

5. FUTURE PROSPECTS

5.1 Deepen the Integration of "Posts, Courses, Competitions and Certificates"

The content of certificate assessment will be deeply integrated into curriculum teaching and practical training tasks to realize the "integration of courses and certificates". At the same time, elements of skill competitions will be actively introduced, with competitions as a driving force to improve students' skill levels, cultivate their teamwork ability, and comprehensively enhance the quality of talent training.

5.2 Expand Resource and Technology Application

Continuously update and enrich online teaching resources, and promptly add content related to cutting-edge technologies. Actively explore the application of artificial intelligence technology in teaching, and use AI to analyze students' learning data, so as to further improve the accuracy and effectiveness of teaching and meet students' diverse learning needs.

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Effective Ways to Cultivate Innovation Consciousness and Ability of Vocational College Students under the Background of Artificial Intelligence

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Abstract: In the context of rapid development of AI technology, cultivating the innovative consciousness and ability of vocational college students is not only the key to enhancing their employment competitiveness, but also an urgent need to promote industrial transformation and upgrading, and serve the national innovation driven development strategy. Vocational education needs to closely integrate technological changes and explore effective training paths and measures that adapt to the characteristics of the AI era.

Keywords: EArtificial Intelligence; Vocational Education; Innovation Capability

1. THE MAIN DIFFICULTIES FACED BY THE CULTIVATION OF INNOVATIVE TALENTS IN HIGHER VOCATIONAL COLLEGES

The disconnection between the curriculum system and industrial demand is a serious problem, which is reflected in the following aspects: some colleges and universities still use the traditional subject oriented curriculum, do not meet the technology update needs of emerging industries, and there are also deficiencies in interdisciplinary integration. The weak construction of the practice platform is also prominent. The training base on campus is disconnected from the actual production of enterprises. The equipment update rate is less than 40%, and the conversion rate of entrepreneurial projects is less than 5%. The talent training mode is relatively single, paying too much attention to the teaching of professional knowledge, ignoring the cultivation of innovation ability and practical ability[1].

In terms of teachers' strength, it is relatively weak. Specifically, about 60% of teachers have no work experience in enterprises and are difficult to teach practical and innovative skills. 72% of the teachers lack interdisciplinary background and have "skill panic" because of the structural contradictions of teachers.

At the same time, there are also problems in the incentive mechanism. The evaluation system focuses on scientific research papers and ignores the contribution of teaching innovation and the integration of production and education[2].

lack of incentive indicators in the evaluation mechanism. The specific performance is as follows: the evaluation standard is single, and it still focuses on the examination results, ignoring the comprehensive quality evaluation such as innovation ability and team cooperation. The credit transfer is not smooth, and the mutual recognition mechanism of innovation and entrepreneurship credits and professional credits has not been popularized. There is a popular "stability seeking" mentality in the concept of employment, and the phenomenon of "slow employment" is increasing, which limits the scope of students' employment choices[3].

2. EFFECTIVE WAYS TO CULTIVATE HIGHER VOCATIONAL COLLEGE STUDENTS' INNOVATIVE CONSCIOUSNESS AND ABILITY

Compulsory/elective courses such as fundamentals of artificial intelligence, application of AI tools and data thinking will be offered to break the mystery of technology. Add innovative thinking training courses (such as design thinking and TRIZ theory), and combine case teaching to improve problem reconstruction ability. Strengthen the discussion on AI ethics and social impact, and guide responsible innovation.

Add "ai+professional" modules (such as "intelligent operation and maintenance", "Ai marketing" and "generative design") in Electromechanical, finance and trade, art design and other specialties. Develop interdisciplinary project courses, such as: smart small workshop (machinery+ai), smart retail sand table (business+data analysis).

Build an intelligent training workshop: introduce industrial robots, digital twin systems and ar/vr equipment to simulate the intelligent factory environment.

Develop virtual innovation laboratory: provide cloud AI development tools (such as automl and low code platform) to reduce the technical threshold.

promote project driven learning mode

Real business topics in the classroom: cooperate with technology companies to let students use AI tools to optimize production processes and analyze customer behavior.

Incubation of innovation projects: set up "Ai Innovation workshop" to support students' development of intelligent product prototypes (such as CV based quality inspection tools and intelligent agriculture assistants).

jointly build Ai industry college and order class

Jointly run schools with AI enterprises such as Huawei, introduce enterprise engineers to teach, and jointly build courses and certification systems.

Set up "Ai Trainer", "intelligent device operation and maintenance" and other new career direction order classes.

Employ enterprise engineers as project mentors to

guide students to participate in technology improvement and process innovation.
The joint venture set up a "minimally invasive new fund" to reward small-scale technological improvement schemes with practical value.
Organize to participate in AI special events (such as robot competition and AI application development competition), and set up a school competition - provincial competition - national competition echelon.
Hold a road show day for innovation achievements, and invite enterprises and investors to participate in the evaluation.
Set up "Ai maker club" to provide technology salon, hacker marathon and other activities.
Build online innovation communities (such as discord Technology Forum) to promote cross professional collaboration.
Increase the weight of process evaluation: record the creative contribution, technological breakthrough and team cooperation performance in the project.
Introduce achievement transformation evaluation: give credits for patent applications and technical solutions adopted by enterprises.
Converting competition awards, technological inventions, entrepreneurial practice, etc. into innovation credits can replace some traditional course credits.
Organize teachers to participate in AI enterprise practice (no less than 6 months in total every 5 years) and master the latest tool chain in the industry.
Set up "Ai Teaching Innovation Award" to encourage teachers to develop teaching cases that integrate AI.
Employ enterprise engineers and experts from scientific research institutes as part-time teachers, and establish a "technology+industry" dual mentor team.

3. CLASSIC CASES IN THE CULTIVATION OF HIGHER VOCATIONAL COLLEGE STUDENTS' INNOVATION CONSCIOUSNESS AND INNOVATION ABILITY

Chongqing Vocational College of electronic engineering has explored the characteristic mode of talent training mechanism of "focusing on seedlings, building workshops, and looking at three forces" in emerging fields such as intelligent manufacturing and artificial intelligence. The mechanism Cultivates Innovative Talents with technical skills through precise selection, practical empowerment and dynamic evaluation. The following are the specific paths and typical practices for its implementation.
Data portrait screening: establish an "innovation potential model" to identify students with good technical foundation and active thinking through data such as enrollment assessment, professional course scores, and skill competition performance.
Dynamic observation mechanism: the teacher team observes the students' hands-on ability and problem-solving willingness (such as whether to actively try AI tools to optimize the process) in the training courses and community activities.
Enterprises' participation in the evaluation: engineers of cooperative enterprises participate in the interview to select students with industrial sensitivity (such as those who show interest in troubleshooting industrial robots).
Establish personal development files for students selected in the "nursery stock", record their technical expertise (such as python programming ability), project participation, and regularly update their growth trajectory.
according to the functional orientation of the workshop, it is divided into: Basic Skills Workshop: mainly mastering the basic operation of AI tools and intelligent devices, which can be subdivided into: industrial robot programming workshop, python data workshop, special Innovation workshop: small projects that mainly solve the real problems of enterprises, such as the "intelligent detection workshop" jointly built with Chang'an Automobile;
Cross domain collaborative workshop: it is mainly a multi-disciplinary team to complete the development of complex systems, such as the establishment of a joint workshop for virtual debugging of intelligent manufacturing production lines. |
The workshop implements the "project bidding system": the enterprise releases the real demand (such as the development of a model of motor fault prediction model), and the student team competes to undertake it.
Introduction of engineer tutor group: the technical backbone of enterprises will be stationed on campus every week for guidance to ensure that the project meets industrial standards (such as Huawei engineers' guidance on 5g module development).
"look at the three forces": the "three forces" of Dynamic Evaluation Oriented by ability output refer to technology application, innovation transfer and team leadership. The evaluation runs through the whole process of training.
Assessment points: operation proficiency of intelligent devices (such as collaborative robot programming), innovative application of AI tools (such as improving quality inspection process with CV algorithm).
Evaluation method: enterprise certification examination (such as obtaining the "industrial robot operator" certificate)+project acceptance defense.
Assessment point: the ability to migrate existing technologies to new scenarios (such as adapting the logistics AGV control algorithm to agricultural robots).
Typical case: the student team migrated the fault diagnosis model of CNC machine tools to the operation and maintenance of wind power equipment, which was adopted by enterprises.
Assessment point: project division and coordination, resource integration ability (such as leading the cross professional team to complete the development of intelligent warehousing system).
Evaluation method: 360 degree evaluation (team members' mutual evaluation+enterprise mentor observation).
Set up a "special fund for seedling cultivation" to support students' participation in international competitions (such as the world skills competition) and the purchase of development kits (such as NVIDIA Jetson edge computing devices).
The "heavy power Huawei AI innovation center" was built to provide hardware support such as Atlas 200 AI acceleration module.
Evaluate the growth progress of "three forces" every semester, and those who fail to meet the standards will

withdraw from the seedling plan, and at the same time absorb new talents (such as students who stand out in the municipal skills competition).

4.4.3. achievement transformation channel

Excellent projects are incubated through the school's "smart innovation space". For example, the AGV scheduling system developed by a student team has been applied to local logistics enterprises in Chongqing.

In 2023, students of the "seedling program" won 37 National Skills Competition Awards, and 56% entered key technical positions in Huawei, BOE and other enterprises.

Industry contribution: the "intelligent welding workshop" jointly built with Thalys automobile has solved 21 production line problems and saved more than 3million yuan.

The core of the mechanism is:

A. Accuracy: avoid talent burial through data+manual double screening;

B. Practical: the workshop project directly meets the needs of the industry and eliminates "paper innovation";

C. Growth: the "three forces" evaluation system continues to lead students' ability upgrading.

This closed-loop design of "selecting seedlings, breeding seedlings and testing seedlings" has realized the transformation of vocational education from "batch training" to "precision forging".

For example, Hunan Electric vocational and technical college, as a "Chuyi" high-level Higher Vocational College in Hunan Province, focuses on the equipment manufacturing industry chain and innovatively puts forward the mode of "integration of education chain, industry chain and talent chain". By deeply connecting with the regional industrial demand, it reconstructs the whole process of talent cultivation and realizes the closed-loop connection from enrollment to employment. This practice of "turning education around industries, majors around enterprises, and learning around posts" has truly realized the resonance of vocational education and regional economy.

Innovation is the soul of higher vocational education. In the AI era, it is more necessary to shift from "skill teaching" to "intelligent creation". By breaking the knowledge barrier through curriculum reconstruction, opening up the practice scene through the integration of production and education, and using cultural infiltration to awaken innovation consciousness, higher vocational colleges are fully capable of cultivating "intelligent" talents who understand technology and are good at innovation. When students learn to use AI tools to solve real problems, the seeds of innovation have taken root.

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Curriculum Reform of College Physics in Higher Vocational Undergraduate Universities

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Abstract: College Physics is a core foundational course for technical majors such as Electrical Engineering and Automation, Mechanical Design and Manufacturing in vocational undergraduate universities. It undertakes the task of connecting basic physical principles with professional application scenarios, and is of great significance to cultivate students' ability to solve practical engineering problems and develop sustainable learning skills. However, in the current teaching practice, this course faces three key problems: the theoretical content is disconnected from professional needs (over-emphasizing classical physics deduction while lacking combination with industrial scenarios like motor operation or equipment heat dissipation), insufficient practical teaching resources (limited laboratory equipment leading to shared operation and insufficient hands-on opportunities), and single evaluation mode (focusing on final exams while ignoring process and practical ability assessment). Aiming at these problems, this paper proposes targeted reform strategies: reconstructing a "professional-oriented" curriculum system (integrating physics knowledge with professional cases), building a "virtual-physical integration" experimental platform (breaking equipment and safety constraints), and implementing a diversified evaluation mechanism (combining theory, practice, process and innovation assessment). The reform aims to improve students' learning enthusiasm, enhance their ability to apply physical principles to professional tasks, and provide solid support for vocational undergraduate universities to cultivate high-level technical and skilled talents.

Keywords: Vocational Undergraduate Universities; College Physics; Curriculum Reform; Virtual-physical Integration; Diversified Evaluation

1. ANALYSIS ON THE TEACHING PROBLEMS AND CAUSES OF COLLEGE PHYSICS IN VOCATIONAL UNDERGRADUATE UNIVERSITIES

As vocational undergraduate education focuses on "technical skills + academic literacy", College Physics, as a basic course, has gradually exposed mismatches with talent training goals in teaching practice. The main problems and their causes are as follows:

1.1 Disconnection between Theoretical Content and Professional Demands

The current College Physics curriculum mainly centers on classical physics knowledge, such as Newton's mechanical laws, electromagnetic field theory and thermodynamics principles, but rarely links these contents with the professional needs of vocational undergraduate majors. For example, when explaining "electromagnetic induction", it only focuses on formula derivation and ignores the connection with the working principle of transformers (a core component in electrical automation); when teaching "thermal conduction", it lacks analysis of heat dissipation design for high-power electrical equipment. Meanwhile, some students have weak basic knowledge (especially spring college entrance examination students who did not systematically learn high school physics), making it difficult to digest abstract theoretical knowledge. The rigid "teacher-centered" teaching mode further reduces students' learning enthusiasm, leading to the phenomenon that "students learn physics but cannot use it in professional practice". This problem is consistent with the common challenge of "disconnected theoretical content and professional needs" in vocational technical courses, as identified in studies on curriculum reform of applied technology courses.[1]

1.2 Insufficient Practical Teaching Resources and Opportunities

College Physics is a course that combines theory and practice, and experimental teaching accounts for nearly 30% of the total class hours. However, most vocational undergraduate universities have limited investment in physics laboratories: the number of experimental equipment such as Helmholtz coil magnetic field testers and vernier calipers is insufficient, resulting in 3-4 students sharing one set of equipment in laboratory classes. Due to limited class time (usually 90 minutes per experiment), some students can only watch group members operate without hands-on opportunities. In addition, laboratories are not open after class, so students who fail to master experimental steps cannot consolidate practice independently. This situation directly leads to students' weak practical operation ability and inability to apply physical experimental methods to solve professional technical problems. Similar to the equipment shortage issue in sensor technology courses, insufficient practical resources in College Physics have become a key bottleneck restricting teaching quality, as practical operation is essential for

students to transform theoretical knowledge into practical skills.[2]

1.3 Single Teaching Evaluation Mode

The traditional evaluation of College Physics mainly relies on the final closed-book exam (accounting for more than 70% of the total score), which focuses on testing students' memory of formulas and theoretical deduction ability, while ignoring the assessment of practical operation, problem-solving and innovation ability. For example, the exam questions mostly involve "calculating the acceleration of gravity" or "deriving the electromagnetic field intensity formula", but rarely include application-oriented tasks such as "analyzing the influence of magnetic field distribution on motor efficiency". This single evaluation mode cannot reflect students' comprehensive quality, nor can it guide students to pay attention to the practical application of physics knowledge, which is inconsistent with the talent training orientation of vocational undergraduate education. As emphasized in vocational education curriculum reform research, a single evaluation system fails to meet the requirements of cultivating technical talents, and diversified evaluation that combines theory, practice and innovation is more in line with the characteristics of vocational education.[3]

2. TEACHING REFORM STRATEGIES FOR COLLEGE PHYSICS IN VOCATIONAL UNDERGRADUATE UNIVERSITIES

To solve the above problems, we should take "serving professional development" and "student-centered" as the core, and promote curriculum reform from three aspects: curriculum system, teaching resources and evaluation mechanism.

2.1 Reconstruct the "Professional-Oriented" Curriculum System

Adjust the curriculum content structure to form a three-module system that connects basic theory with professional application:

Basic Theory Module: Retain core knowledge such as mechanics, electromagnetism and thermodynamics, but simplify overly complex theoretical deductions (e.g., partial differential equations in electromagnetic field theory). Focus on the application of principles, such as explaining "moment of inertia" in combination with the dynamic balance of motor rotors, and teaching "electrostatic field" in connection with electrostatic protection of electrical equipment.

Professional Integration Module: Add 4-6 professional application units, such as "Application of Physics in Electrical Engineering" (covering mechanical vibration and motor fault diagnosis, thermodynamics and battery energy storage) and "Physics Basis of Intelligent Manufacturing" (combining optical principles with sensor signal processing). Each unit is supported by 2-3 enterprise cases (e.g., analyzing the heat dissipation scheme of new energy vehicle motors based on thermal conduction principles).

Practical Innovation Module: Design project-based tasks that simulate industrial scenarios, such as "optimizing the magnetic field distribution of electrical equipment using Helmholtz coils" and "designing a simple heat dissipation structure for electrical components based on thermodynamics laws". Guide students to complete tasks in groups, integrating physics knowledge with professional skills.

2.2 Build the "Virtual-Physical Integration" Experimental Teaching Platform

To make up for the shortage of physical equipment and improve students' hands-on opportunities, we should build a dual experimental platform:

Virtual Simulation Platform: Introduce professional simulation software (e.g., Labster, COMSOL) to develop virtual experimental projects for high-risk, high-cost and difficult-to-reproduce experiments, such as "high-voltage electrical field measurement" and "digital twin motor magnetic field simulation". Students can adjust parameters freely in the virtual environment (e.g., modifying temperature to observe its impact on electrical equipment performance) and conduct repeated operations to deepen their understanding of theoretical knowledge.

Physical Experiment Platform: Optimize the configuration of existing laboratory equipment, increase the number of basic operation tools (e.g., vernier calipers, oscilloscopes) to ensure one set per 2 students. Open the laboratory for 4-6 hours every week after class, and assign full-time teachers to guide students who need to make up experiments or conduct innovative practice.

At the same time, conduct special training for teachers on virtual simulation technology to ensure that they can skillfully use the platform to design teaching scenarios and guide students' experimental operations.

2.3 Implement the Diversified Comprehensive Evaluation Mechanism

Break the single final exam mode and establish a four-dimensional evaluation system with a total score of 100 points:

Theoretical Assessment (40%): Adopt a closed-book exam, with 60% of the questions being application-oriented cases (e.g., "using electromagnetic induction principles to analyze transformer efficiency improvement methods") and 40% being basic knowledge questions, focusing on testing students' ability to apply principles to solve professional problems.

Practical Operation Assessment (30%): Evaluate students' performance in 3 core experiments (e.g., "basic physical quantity measurement", "magnetic field characteristic test"), with assessment indicators including equipment operation standardization (30%), data accuracy (30%) and fault 排查 ability (40%).

Process Assessment (20%): Record students'

pre-class independent learning (through online platform homework), in-class case discussion and after-class experimental report quality, reflecting their learning attitude and progress.

Innovation Assessment (10%): Reward students who propose innovative schemes (e.g., optimizing experimental steps to improve data accuracy, designing physics-based solutions for professional problems), encouraging them to develop innovative thinking.

3. CONCLUSION

College Physics curriculum reform in vocational undergraduate universities is an important part of adapting to the development of vocational education and meeting the needs of industrial upgrading. By reconstructing the "professional-oriented" curriculum system, building the "virtual-physical integration" experimental platform and implementing the diversified evaluation mechanism, we can effectively solve the problems of disconnected content, insufficient practice and single evaluation in current teaching. The ultimate goal of the reform is to make College Physics truly become a "bridge" between basic science and professional technology, help students master the ability to apply physical principles to solve practical engineering problems, and lay a solid foundation for vocational undergraduate universities to cultivate high-quality technical and skilled talents who adapt to the development of modern manufacturing industry.

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Survey and Analysis of Practical Teaching in the Internship of Social Sports Guidance and Management Major (Diving)-- Taking Lingnan Normal University as an Example

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Abstract: The issue of internship and practical teaching is an important component of talent cultivation in universities, serving as a link between theory and practice, a bridge for students to apply theory to practice, and is of great significance for improving students' employability. This study takes the issue of internship and practical teaching as the research object, conducts a questionnaire survey among graduates of the Social Sports Guidance and Management major (Diving) from the past five years, and conducts semi-structured interviews with some students. The survey found that students are relatively satisfied with the duration of internship and practical teaching, and the school's preparation before the internship is relatively sufficient. The main work involved in the internship and practical teaching process is related to diving skills and marketing communication. The internship and practical teaching link has a positive impact on employment, and students are relatively satisfied with the internship and practical teaching link.
Keywords: Social Sports Guidance and Management; Internship; Practical Teaching

1. INTRODUCTION

The internship is an important part of practical teaching, serving as a continuation of the practical training phase, transitioning from simulated exercises in the training phase to practical operations in real organizational positions[1]. Internships are generally arranged during the summer vacation after the end of junior year and throughout the entire senior year, typically from July of each year to April of the following year. The internship period should be continuous to prepare for the completion of the graduation thesis and future career choices[2], and internships are generally conducted at teaching practice bases. These practice bases are typically jointly established by universities, government departments, research institutes, enterprises, and institutions through agreements, and they possess a certain capacity, have relatively fixed locations, and combine both full-time and part-time teachers. They serve as important platforms for students to participate in practical teaching both inside and outside the school. The Ministry of Education has formulated and implemented the National Standard for Teaching Quality of Undergraduate Majors in Physical Education (2018 edition)[3], which is of great significance for regulating professional admission, construction, and evaluation, deepening the comprehensive reform of undergraduate majors in physical education, and further improving the quality of talent cultivation. The basic training objectives of physical education majors emphasize the cultivation of applied talents. This requires not only a systematic grasp of basic theories, skills, and methods of the major, emphasizing a solid foundation and strong quality, but also the ability to apply professional knowledge and skills to professional practice, highlighting a talent type that emphasizes practicality and strong abilities.

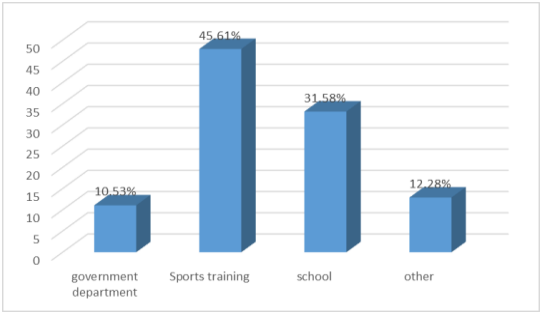

Figure 1 The nature of the work units of the respondents

Lingnan Normal University's Social Sports Management Major (Diving) began enrolling students in 2013, with the training goal of cultivating applied talents in the diving field. This study conducted a survey on graduates from the past five years of this major, with a total of 177 graduates and 105 valid questionnaires received. The survey results showed that 94.74% of the respondents had obtained relevant certificates (such as PADI, CMAS, etc.), but only 14.04% were currently engaged in work related to diving. The nature of their work units (as shown in Figure 1) revealed that the highest proportion was in sports training. Interviews found that the highest proportion of respondents was in the swimming training industry, specifically as swimming coaches. Another 31.58% of the students were teaching in schools. This result can be described as "shocking" and is "far from" the goal of talent cultivation for this major. (As shown in Figure 1) Through investigation and analysis of internship and practical teaching links, this study identified problems in the internship and practical teaching links, with the aim of providing references for the reconstruction of practical teaching links.

2. RESEARCH OBJECTS AND METHODS

2.1 Research Object

This study takes practical teaching issues as the research object, focusing primarily on the internship, practical training, and fieldwork components of practical teaching. Through investigation, the current status of practical teaching is discovered, the causes of existing problems are analyzed, and targeted solutions are proposed.

2.2 Research Methods

2.2.1 Questionnaire survey method

The reliability test of the research questionnaire was conducted based on the test-retest method. Before officially distributing the questionnaire, the author administered it twice to 20 potential respondents, obtaining a correlation coefficient of r=0.86 between the two surveys. The questionnaire was tested for content, structural, and criterion-related validity, and evaluated by experts based on their professional knowledge. This study distributed survey questionnaires to graduates of the Social Sports Guidance and Management (Diving) program from Lingnan Normal University over the past five years, with a total of 177 graduates. Through Wenjuanxing, 110 questionnaires were collected, of which 105 were valid, with an effective rate of 95.5% .

2.2.2 Interview method

This study adopts semi-structured interviews, with interviewees consisting of two parts:

Firstly, an interview outline was designed for the research topic of practical teaching. The interviewees were three experts related to talent practical teaching, the person in charge of the Social Sports Guidance and Management major (diving), the person in charge of the diving direction, and the manager of the Teaching Development and Quality Assessment Center. The interviews were conducted between April 2025, with each interview lasting between 20-30 minutes.

Secondly, an interview outline was designed for the research topic of practical teaching. The interviewees were two students from each grade from 2017 to 2021. The interviews were conducted between May 2025, with each interview lasting between 15 and 20 minutes.

During the interview process, key information is recorded and the interview is audio-recorded to prevent information loss. After each interview, the interview materials are organized to avoid any omissions. An interviewee may be interviewed one or multiple times to obtain rich information. During the actual interview, questions are not specifically formulated, and a relaxed interview is conducted around the interview outline. Questions are asked based on the interview outline, and the order of questions is adjusted according to the interaction. Effective information beyond the preset questions is appropriately expanded.

Table 1 Overview of Survey Respondents

Graduati	Number	Effective	Proportio

on year	of graduates	questionnaires	n
2021	56	31	55%
2022	28	17	61%
2023	30	21	70%
2024	38	22	58%
2025	25	14	56%
Total	177	105	59%

3. RESEARCH RESULTS AND ANALYSIS

The talent cultivation program for the Social Sports Guidance and Management major (Diving) at Lingnan Normal University is generally revised and improved periodically every three years. The subjects of this study are graduates from the past five consecutive years of this major, involving the talent cultivation programs of the 2016 and 2019 editions.

Table 2 Arrangement of internship and practical teaching

Training program version	Credit	Semester	Duration (weeks)
2016	7	6	14
2019	4	7	18

From the perspective of the talent cultivation plan, there is a discrepancy between the credit settings and internship durations in the two versions, which may be related to the credit-based class hours. This needs further verification. The internship period has also been adjusted from the sixth semester to the seventh semester, which is related to the needs of the internship unit. The internship unit hopes that students can continue to work at the internship unit after the internship period ends, as the management process of diving projects follows a certain cycle. The internship period ends just as students transition from novices to skilled workers, so in order to meet the actual needs of the internship unit, the arrangement of the internship time has been adjusted from the sixth semester to the seventh semester. Generally, no other courses are arranged in the eighth semester of this major, which also provides support for the continuity of the internship.

3.1 Satisfaction with the Duration of Practical Teaching in Course Internships

Internship is one of the final stages of practical teaching, built upon the foundation of practical training[4]. It provides a solid foundation for graduation internship work through simulation or "practice" in real-life environments.

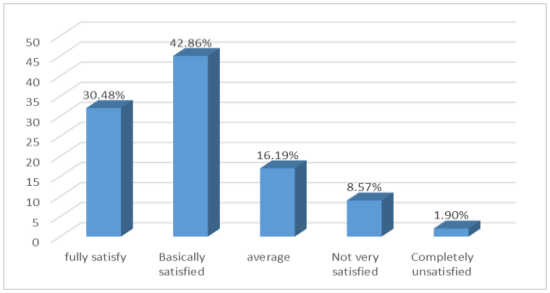

Figure 2 Satisfaction with the duration of internship and practical teaching

The duration of internships has always been a subject of controversy. While the Ministry of Education's documents have clear requirements, in reality, each school has its own considerations, resulting in significant variations in the length of internships and differences in credit calculation. Despite the same semester-long internship, there are considerable differences in credit calculation. According to the talent cultivation plan from 2016 to 2019, the duration of internships has increased from 14 weeks to 18 weeks, which is essentially equivalent to a semester. Survey data indicates that students have a high level of satisfaction with the duration of internships, with a satisfaction rate reaching 73.31%. However, 26.69% of students believe that the duration of internships is insufficient. Interviews reveal that some students prefer to work in clubs throughout their senior year, which is a practical choice. Clubs also perceive the duration of internships as too short. They believe that it's unfair for clubs to train a theoretical "leisure diving" talent to become a skilled worker just before the internship ends. For clubs, accepting interns presents a "dilemma". Therefore, there are diverse perspectives on the duration of internships in talent cultivation plans, with schools, students, and clubs all understanding it from their own perspectives. For schools, it is essential to keep pace with the times and consider the needs of students and clubs without violating the Ministry of Education's documents.

3.2 Preparation by the School before Internship and Practical Teaching

The school places great emphasis on internship and practical teaching, and makes relatively thorough preparations for each step,

such as assigning instructors, signing internship agreements, addressing safety issues, and mobilizing students before the internship.

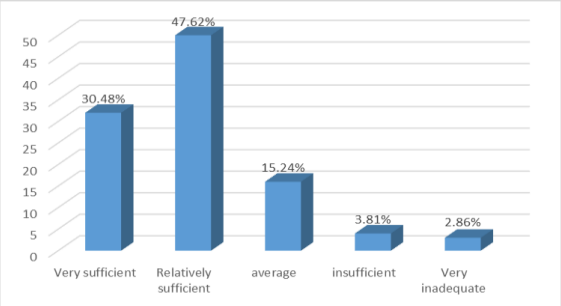

Figure 3 Preparation of the school before internship and practical teaching

Survey data indicates that students are relatively satisfied with the preparations made by the school for the internship. However, there is still some work to be done. Interviews with students reveal that safety is the primary concern. There are loopholes in the internship agreement, and diving is a high-risk project that requires a more comprehensive agreement to constrain stakeholders including students, clubs, and the school, thereby preventing safety issues. Another issue is the diversity of instructors: "Currently, diving graduation internships are only provided with technical guidance from diving instructors. However, diving is a highly comprehensive project that requires knowledge from various fields, such as psychology and marketing. Our guidance should consider multiple aspects, especially as marketing knowledge is rarely practiced in practice. However, once students enter club internships, they are required to have basic marketing practice, which indeed presents a significant practical gap." Therefore, the school needs to do a better job in the preparation stage of graduation internships. The practical training of practical courses must align with the goals of the professional training program, gradually improving the situation of focusing only on diving skills while neglecting marketing theory. If this issue is not addressed, there will be a significant deviation in the club's perception of students, thinking that "college students nowadays are just so-so," gradually improving the practical problem of emphasizing skills while neglecting management and marketing, improving the quality of talent cultivation, and adapting to the needs of diving clubs.

3.3 Main Tasks Involved During the Internship and Practical Teaching Period

There is no legal basis for whether to implement job rotation during graduation internship and practical teaching. It mainly depends on the complexity and professionalism of the products produced by the internship unit. If the professionalism between positions is strong and the entry barriers are relatively high, the job rotation system may not be implemented. This is the main reason. Of course, the second main reason is whether the school has signed a job rotation agreement with the internship unit. If a job rotation agreement is signed, students should undergo job rotation during their internship. Therefore, if the entry barriers between positions are low and the school has signed a job rotation agreement with the training base, job rotation should be implemented.

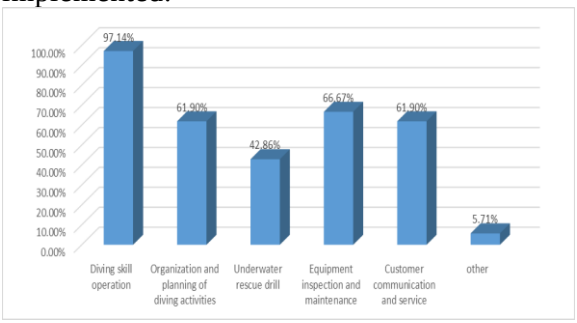

Figure 4 Main work involved during the internship and practical teaching period

Through a survey of graduates from five consecutive years, it was found that diving skills operation accounts for the highest proportion, which is the most basic requirement for diving projects. The second highest is equipment inspection and maintenance, which is the basic condition for safe diving and highly related to the characteristics of diving projects. Diving activity organization and planning is an important content of the club. To expand the market, the club must engage in marketing management, which is an important skill required for intern students and also a characteristic of the social sports guidance and management major. Customer communication and service also account for a high proportion in diving projects, which is related to the market characteristics of diving projects and highly correlated with customer

satisfaction and customer retention. Therefore, the possibility of internship rotation in the social sports guidance and management major is relatively low, and there is no requirement for rotation when signing contracts. Marketing management belongs to the part-time content of diving coach positions. Interviews with students found that "most students' internships are in diving coach positions, and there are very few rotations, which I have never heard of." Interviews with club managers found that "we hope intern students not only have the ability to be diving coaches, but also have marketing skills. From the perspective of long-term club management, we hope intern students can become long-term working partners and gradually enter the middle management of the club, which is also beneficial to the club's development."

3.4 The Role of Internship and Practical Teaching in Employment

Internship and practical teaching are often referred to as graduation internships, as internships come immediately after graduation and are merely a part of university studies. However, internships have a significant impact on the employment of college students. It can be said that this is the first time for college students to truly enter "society" and take up real-life jobs. The theoretical knowledge they have learned before is truly tested during the internship process. On the other hand, internships affect employment and make students more rational in their employment choices.

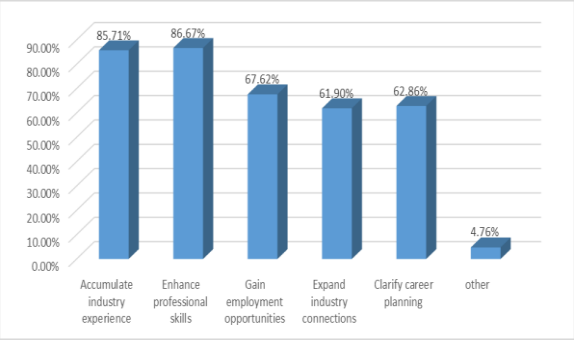

Figure 5 The Impact of Internship and Practical Teaching on Employment

The survey revealed that enhancing vocational skills through internships ranked first, followed by gaining repeated practice in formal job skills. Accumulating industry knowledge and gaining a deeper understanding of the diving industry, such as the market structure of diving and the operation and management of diving clubs, came second. Obtaining employment opportunities ranked third. If the manager of the internship unit believes that the intern student is competent for the corresponding position, there is an opportunity to obtain employment at the internship unit. This should be for students who have performed well during the internship, especially in diving skills, management, and communication. Over 60% of the students have clear career planning choices. The internship and practical teaching links can further clarify students' career choices. During school, they may be more idealistic, but through internships, they gain a deeper understanding of various industries.

3.5 Cognition of Satisfaction towards Internship and Practical Teaching Links

Satisfaction reflects students' cognitive performance in the internship and practical teaching process[5]. A high satisfaction indicates that the internship effect is good and students have a high degree of recognition of the internship process. If the satisfaction is low, it indicates that the internship and practical teaching process needs to be improved.

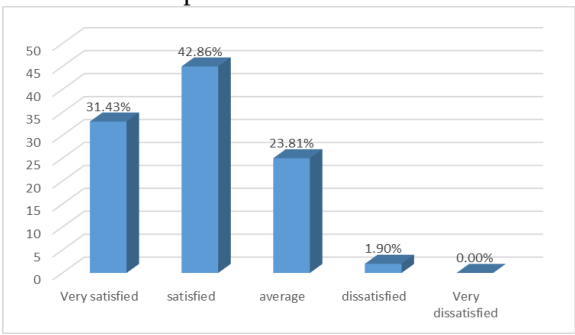

Figure 6 Cognition of satisfaction towards the practical teaching link of graduation internship

Through a survey of students, it is found that their satisfaction with the internship and practical teaching link is relatively high, with a satisfaction rate of 74.29%, exceeding two-thirds. 23.81% of students have a general opinion about the effect of internship and practical teaching, and the dissatisfaction rate is relatively low. Overall, students' satisfaction with graduation internship is still high. However, internships should be viewed rationally and not be treated in isolation. Internships, practical training, and practical

teaching should form a relatively complete closed loop, and the practical teaching links of internships and practical training will have an impact on the effectiveness of internships.

4. CONCLUSION

(1) The chain-like links of practical teaching mainly include probation, practical training, and internship. Internship is the ultimate manifestation of probation and practical training, while probation and practical training are the foundation and prerequisite for internship. The effects of probation and practical training will ultimately be reflected in the internship link.

(2) The survey found that students have a good satisfaction with the duration of internship and practical teaching. The school's preparation before the internship is relatively sufficient. The main work involved in the internship and practical teaching process is related to diving skills and marketing communication. The internship and practical teaching link has a positive impact on employment, and students have a good satisfaction with the internship and practical teaching link.

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Exploration on Teaching Reform of Integrated Circuit Layout Design Course under the Background of Industry-Education Integration

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Abstract: Against the backdrop of industry-education integration, this paper addresses long-standing "pain points" in the teaching of the Integrated Circuit Layout Design course. Centered on educational objectives and the OBE (Outcome-Based Education) concept, we have signed school–enterprise cooperation projects and implemented an in–depth "five–dimensional integration" course reform. By introducing real enterprise project cases, adopting project–driven teaching methods, and establishing a diversified evaluation system, we have effectively enhanced students' practical and innovative abilities. This provides a valuable reference for cultivating high–quality application-oriented talents that meet the needs of the industry.

Keywords: Industry–education integration; Integrated circuit layout design; OBE; Practical ability; Innovation ability

1. INTRODUCTION

With the rapid development of information technology, the integrated circuit industry has become a strategic, fundamental, and advanced production industry that supports economic and social development and ensures national security. As a key link in the integrated circuit industry chain, the cultivation of integrated circuit layout design talents is crucial. This article analyzes the problems in the current teaching of integrated circuit layout design courses from the perspective of industry education integration, and explores the depth of curriculum teaching reform based on industry demand. Centered around the educational goals and Outcome Based Education (OBE) outcome oriented educational philosophy, with students at the center, integrating industry needs into the entire process of talent cultivation, proposing innovative measures of "four-dimensional core" for reforming teaching concepts (why to change), teaching content (what to do), teaching mode (how to teach), and teaching forms (what to support), carrying out a five dimensional integrated teaching reform that deeply integrates theory and practice, namely resource sharing, content construction, collaboration between teachers and experts, and talent evaluation[1].

2. ANALYSIS OF PAIN POINTS AND ISSUES

In the context of the integration of industry and education, the traditional teaching mode of integrated circuit layout design course can no longer meet the industry's demand for high-quality applied talents. The main pain points are as follows:

The course objectives focus too much on imparting theoretical knowledge and lack the cultivation of students' engineering practical ability, professional ethics, and innovation ability, which makes it difficult for graduates to quickly adapt to the job demands of enterprises. Moreover, students lack communication and exchange with real industries, and the course content is relatively outdated, unable to reflect new technologies and processes in a timely manner, resulting in a disconnect between the knowledge they learn and reality[2].

Teachers lack the latest engineering practice experience and insufficient experimental teaching resources. In the classroom, they focus more on theoretical explanations, while students lack practical case analysis and real project experience, making it difficult to combine theoretical knowledge with practice and effectively cultivate students' engineering practice ability and innovation consciousness[3-6].

The traditional "cramming" teaching method is difficult to stimulate students' learning enthusiasm, as they passively receive knowledge and lack the ability to think actively and solve problems.

1.4 Single evaluation system

The traditional evaluation system places too much emphasis on final exam scores, neglects students' performance and progress in the learning process, makes it difficult to comprehensively evaluate students' learning outcomes, and lacks evaluation of students' engineering practice ability, teamwork ability, communication and expression ability, and other aspects.

3. EXPLORATION OF TEACHING PHILOSOPHY REFORM

In order to improve the quality and effectiveness of teaching, address the "pain points" in the curriculum, and achieve a true connection between skill development and job requirements, the curriculum team has signed a horizontal project with the enterprise. I hope to achieve a close integration between course content and the actual needs of enterprises through project cooperation, enhance the practicality and pertinence of teaching, and enable

students to be exposed to real professional environments, understand the operation and management of enterprises, master vocational skills and practical experience, and truly achieve deep integration of learning and research[7-9].

The course team conducts in-depth analysis with enterprises on industry development trends and job skill requirements, and combines school resources to optimize and improve the existing curriculum system. Jointly develop talent training plans and curriculum standards that meet market demand and industry development trends in talent cultivation. Through the OBE outcome oriented education philosophy, learning outcomes are clearly defined, and the training objectives are decomposed into ability indicators. Specifically, the expected learning outcomes of the course, the reverse deduction of the training path, and the assessment methods of the course are shown in Table 1, and "professional ethics" are embedded in the assessment for ideological and political integration.

Resource sharing is the foundation of school enterprise cooperation and a prerequisite for achieving subsequent cooperation. Through resource sharing, teachers and enterprises can integrate their respective advantageous resources and achieve complementary advantages.

Combining enterprise technology and industry standards, schools and enterprises collaborate to develop teaching resources, integrate teaching theory knowledge base and industry case library. The course group teachers are responsible for building the theoretical part, while the enterprises are responsible for building real cases, developing three-dimensional teaching resources such as multimedia teaching courseware, teaching cases, question banks, and enterprise project cases for joint use by students and enterprises in our school. Establish a school enterprise joint laboratory and utilize the genuine Huada Jiutian EDA software equipped in the school laboratory to provide EDA training for students and new employees in enterprises. And teachers and enterprise engineers, as the dual main line, have jointly tailored the campus textbook "Fundamentals of Integrated Circuit Layout Design - Based on BGI Nine Days Aether" for students in this major, which has a higher degree of matching with the course[10].

Schools and enterprises sign horizontal projects, jointly developing projects based on the cutting-edge technology needs of the integrated circuit industry and practical problems of enterprises, and leveraging their respective advantages. Course group teachers have a solid theoretical foundation and cutting-edge research perspective, which can provide theoretical support and solutions for technological innovation in enterprises, and promote technological breakthroughs; Enterprise engineers have rich industry experience and market demand insight, which enables them to transform practical problems into scientific research topics, promote technological innovation, accelerate the transformation and application of scientific research results, and enhance the market competitiveness of enterprises. The practical experience accumulated by teachers in projects can reflect teaching, optimize curriculum design, enhance students' engineering practical abilities, and reserve talents for enterprises.

The course team has established deep cooperative relationships with enterprises to create a seamless platform for students to transition from theoretical learning to practical application. Studying theoretical knowledge in school to prepare for internships and work. Enterprises provide internship positions for students, covering key aspects such as chip design, manufacturing, packaging and testing, allowing students to exercise their skills in real work environments. During the learning process, students not only have access to cutting-edge technology in the industry, but also receive guidance from corporate mentors and accumulate valuable project experience. This school enterprise collaborative education model not only meets the demand of enterprises for high-quality technical talents, but also lays a solid foundation for students' career development, achieving a win-win situation between education and industry.

4. EXPLORATION OF TEACHING CONTENT REFORM

In school enterprise cooperation, "content co construction" is a key link to achieve deep integration of teaching and industry. Schools and enterprises jointly analyze and research typical job requirements, organically combine job skills with curriculum systems, and integrate practical cases, new technologies, and new processes from enterprises into teaching content. The school relies on enterprise resources to build practical teaching bases and carry out practical teaching of "real environment, real projects, and real products".

Enterprises are deeply involved in school curriculum design, integrating the latest industry technology standards and job skill requirements into the course content, ensuring that the course content is closely integrated with the actual needs of enterprises, and building a "platform+module+advanced" course system. The 'platform' is the fundamental part of the curriculum system, aimed at providing students with a solid theoretical foundation and general skills, and is the core content that all students must master. Module "is a course designed based on different job requirements and student interests, aimed at cultivating students' in-depth abilities and practical skills in specific directions, and meeting their personalized needs. 'Advanced' refers to students who, after mastering basic knowledge and professional skills, enhance their comprehensive and innovative abilities through higher-level learning and practice. Students can choose more challenging and

cutting-edge course content or project practices based on their own interests and future career development directions, further expanding their knowledge and skill levels. For example, they can transform course content into subject competition content, patents, or innovation projects.

Through school enterprise cooperation, we introduce schools, enterprises, and talents to form a "five in" industry education integration system of "enterprises entering campuses, engineers entering classrooms, engineering cases entering courses, teachers entering projects, and students entering construction sites", forming a development pattern of benign interaction and complementary advantages between schools and enterprises, while allowing students to understand enterprises.

Through deep cooperation with enterprises, schools can integrate actual projects, cutting-edge technologies, and industry standards into teaching content. For example, integrating the training content of the national 1+X vocational skill level certificate into the professional talent training program and curriculum system, and conducting final assessments in the form of the school level quality education project "Integrated Circuit Layout Competition", using competitions as a substitute for exams. Ultimately, distinctive talent training models such as "integration of job certification, course certification, and competition education" will be formed, and a curriculum system integrating "courses, certificates, positions, and competitions" will be constructed.

5. EXPLORATION OF TEACHING MODE REFORM

The curriculum team has been committed to building a high-quality "dual teacher" teaching team. 60% of the teachers in the course group of "Integrated Circuit Layout Design" are double shoulder teachers with many years of experience in enterprise work of integrated circuit layout design, which perfectly fits the course.

Hire enterprise experts and engineers as part-time teachers to regularly teach students. Enterprise engineers bring cutting-edge technology and practical project experience into the teaching process, not only closely integrating course content with job requirements, but also allowing students to understand industry trends in advance, enhancing practical abilities and career adaptability, while increasing students' interest and enthusiasm for learning. By combining real-life cases with classroom theoretical knowledge, students can learn while doing, achieving the goal of "learning by doing, learning by doing". Through learning and experiencing the real work process, students have truly achieved a seamless integration of learning and job teaching. After completing this course, they can directly apply for the position of "Integrated Circuit Layout Design Engineer", which is in high demand in the industry.

Regular visits by course group teachers to enterprises for lectures, exchanges, and learning can not only enhance teachers' practical abilities, understand the latest processes, and conduct real-time technological updates, but also integrate case studies from actual projects into teaching. Through this method of deep integration between schools and enterprises, teachers can gain a deep understanding of cutting-edge technologies in the industry, actual needs of enterprises, and production processes, providing real cases and practical guidance for subsequent teaching, ensuring that teaching content is accurately aligned with the job requirements of enterprises.

Both schools and enterprises shall jointly develop scientific and reasonable evaluation standards, covering students' professional knowledge, practical ability, innovation ability, and professional ethics, etc. The evaluation shall be jointly conducted by curriculum group teachers and enterprise engineers. Evaluation runs through the entire process of student development, evaluating from multiple dimensions and emphasizing process assessment. The theoretical part is evaluated by the teacher, accounting for 15% of the total grade; The experimental part is evaluated by the enterprise mentor, accounting for 25% of the total score; The final assessment is conducted in the form of the school level quality education project "Integrated Circuit Layout Design Competition", using the competition as a substitute for the exam, accounting for 60% of the entire course assessment. The assessment results are statistically analyzed to see the expected learning outcomes achieved, in order to facilitate continuous improvement in the next round of teaching.

The first prize winning works of the "Integrated Circuit Layout Design Competition" every Monday will invite enterprise mentors to provide professional feedback on modifications, allowing students to continue optimizing and transforming them into academic competitions, patents, and other achievements.

6. EXPLORATION OF TEACHING FORM REFORM

The course introduces the "flipped classroom" teaching format, guiding students to watch high-quality MOOCs for preview before class, and understanding students' mastery level through online test questions. In class, the main focus is on explaining key points and easy to make mistakes. Simple knowledge points are briefly covered, and interaction with students is relatively short. Assign layered homework after class and continuously improve based on student feedback. Put low-level cognitive tasks (memory, comprehension) before class, and focus on higher-order abilities (application, analysis, creation) in class. Through teacher to student teaching, student to student teaching, real-time interaction, and research and exploration, we help students master theoretical knowledge.

In order to enhance students' interest in learning and

increase their motivation for self-directed learning. We will expand the location of course implementation from traditional classrooms and laboratories to post class "workshops". Workshop "is a laboratory that is open 24/7, using a" reservation system+self-management ", supporting evening/weekend use. Students can discuss and exchange ideas, do some expansion training and competitions at any time inside, and also provide a place for students to expand their thinking.

6. CONCLUSION

Guided by the OBE outcome oriented educational philosophy, we will reform the curriculum through the integration of industry and education, cultivate high skilled talents in integrated circuits, and achieve the expected learning goals. Through reform measures, students' enthusiasm for self-directed learning, innovative practical ability, and teachers' research level have been significantly improved. It is hoped that this can play a supporting and guiding role in the transformation and upgrading of traditional majors and the cultivation of high-quality innovative skilled talents.

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