

DIGITAL EMPOWERMENT IN K-12 CHINESE WRITING INSTRUCTION: RESEARCH ON PERSONALIZED LEARNING STRATEGIES AND PRACTICE MODELS

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Abstract: Addressing the core challenges of "homogenized teaching models" and "delayed feedback" inherent in traditional K-12 Chinese writing instruction, this study aims to construct a new data-driven paradigm for personalized writing instruction. Employing a mixed-methods research design, the study utilizes quasi-experimental methods and triangulation strategies to verify the effectiveness of digital tools throughout the entire writing process. First, the study constructs a student-centered, four-dimensional personalized learning strategy model comprising "diagnosis, intervention, feedback, and assessment," alongside a functional mapping system for digital tools. Second, empirical analysis based on pre-test, post-test, and delayed-test data reveals that this strategy significantly enhances students' writing performance, language construction capabilities, and metacognitive levels, while demonstrating differential gains among students with varying proficiency levels. Finally, the study explores the synergistic mechanism between AI-based intelligent correction and peer review. This study not only confirms the efficacy of digital tools in resolving the conflict between individual student needs and large-scale instruction but also provides a theoretical basis and practical pathways for resource allocation, teacher professional development, and the establishment of ethical norms within the context of the digital transformation of education.

Keywords: Digital writing instruction; Personalized learning strategies; Data-driven; Core literacy; Education; K-12 Chinese language

1 INTRODUCTION

1.1 The Context of the Era of Digital Transformation in Education

With the rapid development of information technology, artificial intelligence (AI) and big data are reshaping the field of education, playing a pivotal role particularly in the transformation of instructional modalities. Currently, educational informatization has become a significant trend in global educational reform, and the contextual landscape of digital education transformation is primarily manifested in the following aspects, as illustrated in Figure 1. First, the explicit requirements regarding the integration of information technology outlined in the New Curriculum Standards provide clear policy orientation for educational digitization. These standards emphasize the cultivation of students' information literacy and innovative capabilities, necessitating that teachers actively integrate information technology into instruction to facilitate students' adaptation to the learning demands of the digital age. For instance, the application of intelligent tutoring systems can offer personalized learning pathways for students, thereby achieving the objectives of differentiated instruction. Second, the convergence of artificial intelligence and big data technologies has brought revolutionary changes to instructional modalities[1]. The application of AI technologies in education, such as intelligent tutoring systems and automated grading systems, enables the real-time collection and analysis of student learning data, providing teachers with precise instructional feedback. Statistics indicate that students utilizing AI-assisted instruction demonstrate an average increase in learning efficiency of over 15%. Furthermore, big data analytics can reveal deep-seated patterns in student learning behaviors, contributing to the optimization of pedagogical strategies. Through the mining of student learning data, specific difficulties and weaknesses encountered during the learning process can be identified, allowing for the adjustment of teaching methods and content to enhance instructional effectiveness. Currently, Chinese writing instruction in primary and secondary schools faces a series of practical dilemmas. The phenomenon of instructional homogenization makes it difficult to satisfy students' personalized needs, exacerbating the contradiction between individual differences and unified teaching models. Simultaneously, the latency of feedback mechanisms severely constrains the iterative improvement of students' writing abilities. Therefore, within the context of digital education transformation, establishing a new paradigm of data-driven, personalized writing instruction appears particularly crucial[2]. This paradigm can utilize real-time data monitoring and intelligent feedback to assist students in identifying and correcting errors during the writing process, thereby enhancing their writing proficiency. In conclusion, the era of digital education transformation demands that educators possess not only keen technological insight but also profound educational understanding to adapt to the opportunities and challenges brought about by this transformation.

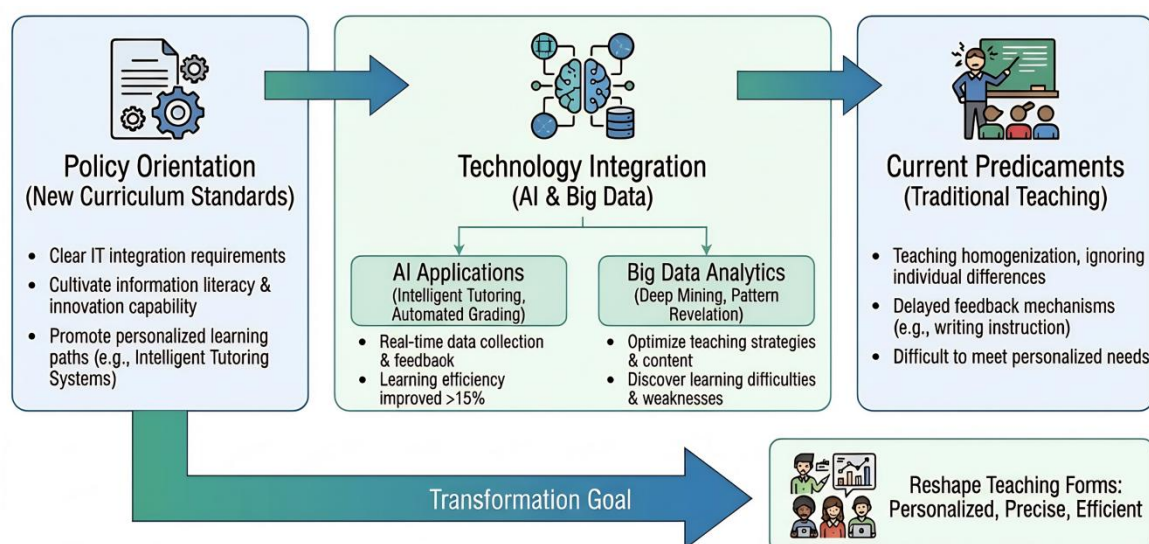


Figure 1 AI & Big Data Driven Digital Transformation in Education: Context, Applications, and Challenges

1.2 The Reality Dilemmas of Writing Instruction in Primary and Secondary Schools

In current educational practice, Chinese writing instruction in primary and secondary schools faces multiple dilemmas. Among these, feedback latency is a critical factor constraining the iterative improvement of students' writing abilities. Since assessment and feedback in writing instruction usually rely on teachers' individual judgments, this limits the speed and quality of feedback to a certain extent. Research indicates that timely and targeted feedback is paramount for the development of writing skills[3]. On one hand, the latency of feedback causes students to remain unaware of problems in their writing for an extended period, preventing timely adjustment and improvement. This delay not only diminishes the efficacy of writing training but also lowers students' learning motivation. For instance, it may take a week or longer from submission to feedback, during which time students may have already forgotten their train of thought and feelings at the time of writing. On the other hand, due to increased teacher workload, traditional feedback methods often focus on the final product of the composition, neglecting the importance of the writing process. Such methods make it difficult to provide real-time monitoring and guidance on the development of thinking and language expression during the writing process. Statistics show that when grading, teachers often focus more on the standardization of language and content, while guidance on writing strategies and thinking processes is relatively limited. Furthermore, the issue of feedback homogenization merits attention. Due to a lack of personalized feedback, individual differences among students are not fully respected or considered. Every student has a unique writing style and way of thinking; standardized feedback fails to adequately meet personalized needs, further exacerbating the contradiction between instructional homogenization and individual differences. Therefore, to overcome these dilemmas, it is necessary to explore new pedagogical pathways[4]. By introducing a data-driven personalized writing instruction paradigm, dynamic monitoring and immediate feedback of the entire writing process can be achieved, thereby improving the efficiency and effectiveness of instruction. This paradigm shift not only facilitates the resolution of the feedback lag problem but also provides personalized guidance for every student, promoting the continuous improvement of their writing capabilities.

1.3 Research Objectives and Core Value Positioning

This study aims to construct a new paradigm of data-driven personalized writing instruction to address issues such as the intensifying contradiction between instructional homogenization and individual differences, and the constraint of feedback lag on the iterative improvement of writing ability in current primary and secondary school Chinese writing instruction. Specifically, the research objectives and core value positioning are as follows, as illustrated in Figure 2: First, by integrating personalized learning theories and writing instruction theories, a student-centered four-dimensional driver structure is designed, comprising diagnosis, intervention, feedback, and assessment. This structure aims to achieve dynamic regulation through data flow permeating the entire writing process, facilitating the personalized improvement of each student's writing ability[5]. The core of this paradigm lies in identifying individual differences through data-driven strategies and providing customized writing support, thereby driving the digital transformation of writing instruction. Second, a digital tool functional mapping system is constructed to provide technical support for writing instruction. In the front-end ideation stage, mind mapping tools and intelligent content recommendations are utilized to assist creative conception; in the mid-stage drafting phase, real-time grammar detection and style adaptation suggestions are implemented to help polish the text; in the back-end revision stage, multi-dimensional evaluation reports and revision path navigation are provided to guide self-correction. The establishment of this system aims to enhance the effectiveness and efficiency of writing instruction and achieve the optimal allocation of writing resources. Third, the research is dedicated to building a support architecture for core competency development, providing support for students' comprehensive development through the design of data-based representation indicators for language

construction ability and dynamic monitoring dimensions for cognitive development levels. This not only aids in the enhancement of writing ability but also promotes the synchronous improvement of cognitive quality and language literacy. Furthermore, the core value of this study lies in promoting the bidirectional empowerment of theoretical innovation and frontline practice. On one hand, the study provides theoretical support and reference for future research in related fields through the construction of a theoretical framework; on the other hand, through empirical research, it verifies the validity of the proposed strategies, providing practical guidance for the reform of primary and secondary writing instruction. Statistics indicate that adopting the data-driven personalized writing instruction paradigm significantly improves students' writing abilities[6]. For example, in a pilot study in a certain region, the experimental group's writing scores increased by an average of 15%, and individual differences were effectively addressed. These results demonstrate that the theoretical and practical value of this research is significant for promoting educational equity and improving educational quality.

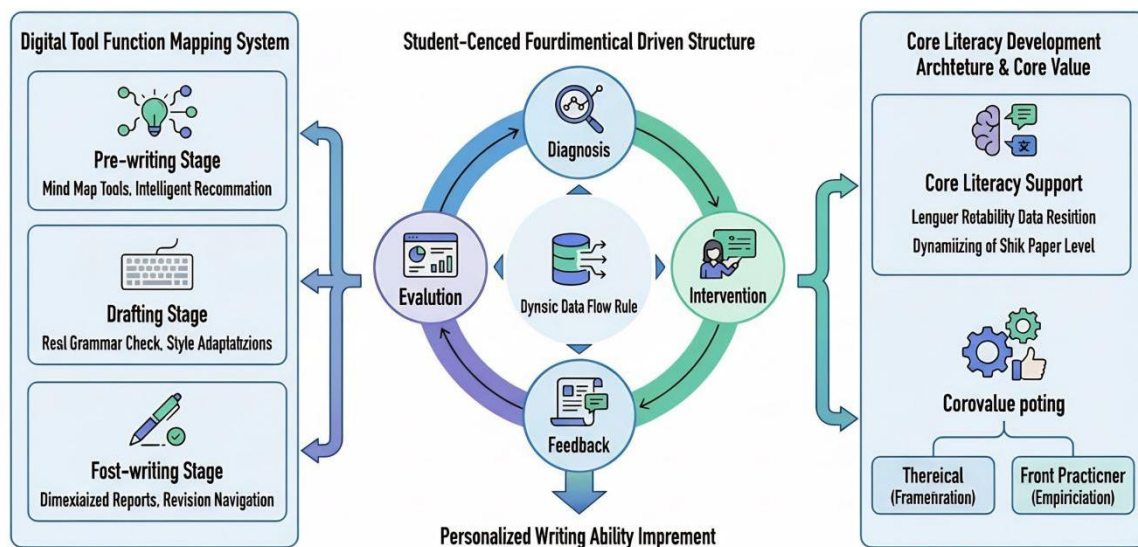


Figure 2 Research Framework for Data-Driven Personalized Writing Teaching Paradigm

2 LITERATURE REVIEW

2.1 The Developmental Trajectory of Personalized Learning Theory

The development trajectory of personalized learning theory traces back to early explorations of differentiated instruction, centering on attending to individual differences and achieving personalized adaptation of instructional content. Differentiated instruction posits that due to variations in students' knowledge backgrounds, cognitive styles, and learning motivations, uniform teaching methods often fail to meet all students' learning needs. With the advancement of educational technology, personalized learning theory has gradually integrated concepts of computer-assisted instruction, propelling the birth of adaptive learning systems. These systems utilize modern educational technologies, such as artificial intelligence and big data analytics, to monitor students' learning processes in real-time and dynamically adjust learning content based on personalized characteristics. The development of such systems has evolved from simple personalized recommendations to the construction of complex cognitive models, enabling more precise targeting of student learning needs and the provision of customized learning resources. In recent years, embodied cognition theory has offered a new perspective for personalized learning theory. Embodied cognition emphasizes the vital role of learners' physical activities, perception, and situational interaction in the learning process. Within the context of personalized learning, tool interaction and learning perception have become research hotspots. Studies indicate that tools serve not merely as learning resources but as extensions of learners' cognitive activities, influencing learning outcomes by altering learners' cognitive load and interaction modes[7]. In the domain of tool interaction, researchers have explored the impact of various digital tools on the learning process. For instance, intelligent tutoring systems can simulate the guidance of human teachers, providing personalized learning suggestions; cognitive tools, such as concept maps and mind maps, help learners organize and integrate knowledge by facilitating thinking activities. Meanwhile, research on learning perception focuses on learners' psychological experiences when using these tools, such as learning motivation, self-efficacy, and cognitive load. Statistics show that personalized learning systems can significantly enhance learners' learning effectiveness and satisfaction. However, research in this field is still in a developmental stage, facing challenges regarding how to ensure system scalability, usability, and cost-effectiveness while maintaining personalized learning effects. As technology progresses and theories deepen, the development of personalized learning theory will continue to provide new methods and insights for educational practice.

2.2 Core Dimensions of Writing Instruction Theory

As an application of social constructivist pedagogical concepts in writing instruction, peer assessment is receiving increasing attention from educational researchers. Social constructivism holds that learning is a social process, and knowledge is constructed through interactions between individuals and others. The value of peer assessment lies in its ability to promote the enhancement of writing skills and cognitive development through cooperation and communication among students. Research indicates that peer assessment helps students examine their own writing from different perspectives, thereby improving writing quality. In the writing instruction process, students are not only recipients of knowledge but also co-creators. Through interaction among peers, students can obtain immediate feedback, which includes not only guidance on writing techniques but also suggestions regarding content and structure. The value of peer assessment is manifested in several aspects: First, peer assessment helps cultivate students' critical thinking and self-reflection abilities. When evaluating peers' writing, students need to employ critical thinking to analyze the strengths and weaknesses of the text; this analytical ability is equally applicable when evaluating their own work. Furthermore, by reflecting on peer feedback, students can better understand their own writing processes, thus promoting the enhancement of self-reflection abilities. Second, peer assessment fosters cooperation and communication among students[8]. During the mutual evaluation process, students need to communicate with each other and share writing insights, which not only enhances friendship among students but also promotes the dissemination of writing skills. Through collaboration, students can better understand writing norms and techniques, thereby improving their writing levels. Third, peer assessment helps stimulate students' learning motivation. In the process of evaluating peers, students can experience the fun and value of writing; this positive emotional experience can stimulate students' interest in learning, thereby improving the actual effectiveness of writing instruction. Additionally, peer assessment can promote the development of students' metacognitive abilities. When evaluating peers' writing, students need to use metacognitive strategies such as planning, monitoring, and evaluating, which are crucial for improving writing abilities. However, the implementation of peer assessment also faces challenges, such as the subjectivity of evaluation standards and the assurance of evaluation quality. Therefore, when guiding peer assessment, teachers need to provide clear standards and guidance to ensure the fairness and validity of the evaluation. Statistics show that in schools adopting peer assessment, students' writing abilities have improved significantly. For example, a study targeting high school students found that after one semester of peer assessment training, students' writing scores increased by an average of 15%. This indicates that the value of peer assessment in writing instruction cannot be ignored. In summary, as one of the core dimensions of writing instruction theory, peer assessment not only helps improve students' writing abilities but also promotes the development of students' critical thinking, self-reflection, and collaborative communication skills. Therefore, in future writing instruction, teachers should fully tap into the potential of peer assessment and create more interaction opportunities for students to achieve the goals of writing instruction[9].

2.3 Application Research of Digital Tools in Language Teaching

As a type of digital tool, online collaborative platforms have brought new perspectives and methods to language teaching. Empirical research indicates that such platforms can facilitate the formation of writing communities, thereby enhancing students' writing abilities. By establishing online collaborative platforms, students can engage in writing exercises, interactive communication, and peer assessment on the platform, thus breaking the spatiotemporal limitations of traditional writing instruction. First, online collaborative platforms help stimulate students' interest and motivation in writing. Students can publish their own works on the platform and receive immediate feedback from peers and teachers; this interactivity can ignite students' enthusiasm for writing. Statistics show that among students using online collaborative platforms for writing, over 80% expressed a stronger interest in writing. Second, online collaborative platforms help improve the quality of students' writing[10]. The platforms provide functions such as real-time error correction, grammar detection, and style suggestions, allowing students to discover and correct their errors in a timely manner during the writing process. In addition, the platforms support peer assessment, enabling students to read, evaluate, and modify each other's works, thereby improving writing levels. Research shows that compositions that have undergone peer assessment are generally of higher quality than those that have not. Furthermore, online collaborative platforms help cultivate students' collaborative and social capabilities. On the platform, students need to communicate and collaborate effectively with peers to jointly complete writing tasks. This interactivity helps cultivate students' team awareness and collaborative abilities. Simultaneously, by reading and evaluating others' works, students can broaden their horizons and improve their social skills. However, the application of online collaborative platforms in language teaching also faces some challenges. For instance, the use of platforms requires certain technical support, and the information technology literacy of teachers and students becomes a constraining factor[11]. Moreover, the use of certain functions on the platform may lead students to rely too heavily on technology, neglecting the cultivation of the essence of writing ability. In summary, as a digital tool, the application of online collaborative platforms in language teaching possesses significant advantages, capable of promoting the formation of writing communities and improving students' writing abilities and comprehensive qualities. However, at the same time, teachers and students should utilize platform functions rationally, focusing on the integration of information technology and language teaching to achieve better instructional effects.

2.4 Existing Research Gaps and Breakthroughs of This Study

Although existing research has made certain progress in the field of personalized writing instruction, significant gaps remain[12]. First, the systemic absence of a diagnosis-intervention closed-loop strategy model limits the precision and efficiency of writing instruction. Most studies remain at the level of optimizing individual instructional segments, lacking an overall design that integrates diagnosis, intervention, feedback, and assessment throughout the entire writing process, thus making it difficult to form a continuously effective instructional cycle. Second, the weak correlation between full-process writing support and core competencies represents another deficiency in existing research. Although digital tools are widely used in writing instruction, they are often limited to specific stages, such as grammar correction or peer assessment, neglecting the fact that writing is a complex mental activity process that requires comprehensive support from conception and drafting to revision. Furthermore, there is a lack of effective alignment between these tools and the development of students' core competencies, failing to fully mine the impact of data-driven personalized instruction on cultivating students' higher-order thinking and creativity. This study aims to break through the limitations of these existing studies. First, by constructing a student-centered four-dimensional driven personalized writing learning strategy model, the links of diagnosis, intervention, feedback, and assessment are organically combined to form a complete closed loop, aiming to improve the pertinence and continuity of instruction. Second, this study will develop a full-process writing support system that not only covers all stages of writing but also achieves dynamic regulation through data flow to provide personalized support. This system will combine mind mapping tools and intelligent material recommendations in the front-end ideation stage, real-time grammar detection and style adaptation suggestions in the mid-stage drafting phase, and multi-dimensional evaluation reports and revision path navigation in the back-end revision stage. Finally, this study will explore the correlation between digital tools and the development of core competencies, designing data-based representation indicators for language construction ability and dynamic monitoring dimensions for cognitive development levels, with the expectation of promoting students' comprehensive development in personalized writing instruction[13]. Through the aforementioned research design and practice, this study is expected to fill the gaps in existing research and provide a new theoretical framework and practical model for personalized writing instruction.

3 LITERATURE REVIEW

3.1 The Developmental Trajectory of Personalized Learning Theory

The development trajectory of personalized learning theory can be traced back to early explorations of differentiated instruction, the core of which lies in attending to individual differences and achieving the personalized adaptation of instructional content. The concept of differentiated instruction posits that due to variations in students' knowledge backgrounds, cognitive styles, and learning motivations, uniform teaching methods often fail to meet the learning needs of all students. With the development of educational technology, personalized learning theory has gradually integrated the concepts of computer-assisted instruction, propelling the birth of adaptive learning systems. Adaptive learning systems utilize modern educational technologies, such as artificial intelligence and big data analytics, to monitor students' learning processes in real-time and dynamically adjust learning content based on personalized characteristics. The development of such systems has evolved from simple personalized recommendations to the construction of complex cognitive models, enabling a more precise targeting of student learning needs and the provision of customized learning resources. In recent years, embodied cognition theory has offered a new perspective for personalized learning theory. Embodied cognition emphasizes the vital role of learners' physical activities, perception, and situational interaction in the learning process. Within the context of personalized learning, tool interaction and learning perception have become research hotspots. Studies indicate that tools serve not merely as learning resources but as extensions of learners' cognitive activities, capable of influencing learning outcomes by altering learners' cognitive load and interaction modes. In the domain of tool interaction, researchers have explored the impact of various digital tools on the learning process[14-17]. For instance, intelligent tutoring systems can simulate the guidance of human teachers, providing personalized learning suggestions; cognitive tools, such as concept maps and mind maps, help learners organize and integrate knowledge by facilitating thinking activities. Meanwhile, research on learning perception focuses on learners' psychological experiences when using these tools, such as learning motivation, self-efficacy, and cognitive load. Statistics show that personalized learning systems can significantly enhance learners' learning effectiveness and satisfaction. However, research in this field is still in a developmental stage, facing challenges regarding how to ensure system scalability, usability, and cost-effectiveness while maintaining personalized learning effects. As technology progresses and theories deepen, the development of personalized learning theory will continue to provide new methods and insights for educational practice.

3.2 Core Dimensions of Writing Instruction Theory

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which includes not only guidance on writing techniques but also suggestions regarding content and structure. The value of peer assessment is manifested in several aspects: First, peer assessment helps cultivate students' critical thinking and self-reflection abilities. When evaluating peers' writing, students need to employ critical thinking to analyze the strengths and weaknesses of the text, an analytical ability that is equally applicable when evaluating their own work. Furthermore, by reflecting on peer feedback, students can better understand their own writing processes, thus promoting the enhancement of self-reflection abilities. Second, peer assessment fosters cooperation and communication among students. During the mutual evaluation process, students need to communicate with each other and share writing insights, which not only enhances friendship among students but also promotes the dissemination of writing skills. Through collaboration, students can better understand writing norms and techniques, thereby improving their writing levels. Third, peer assessment helps stimulate students' learning motivation. In the process of evaluating peers, students can experience the fun and value of writing; this positive emotional experience can stimulate students' interest in learning, thereby improving the actual effectiveness of writing instruction. Additionally, peer assessment can promote the development of students' metacognitive abilities. When evaluating peers' writing, students need to use metacognitive strategies, such as planning, monitoring, and evaluating, which are crucial for improving writing abilities. However, the implementation of peer assessment also faces challenges, such as the subjectivity of evaluation standards and the assurance of evaluation quality. Therefore, when guiding peer assessment, teachers need to provide clear standards and guidance to ensure the fairness and validity of the evaluation. Statistics show that in schools adopting peer assessment, students' writing abilities have improved significantly. For example, a study targeting high school students found that after one semester of peer assessment training, students' writing scores increased by an average of 15%. This indicates that the value of peer assessment in writing instruction cannot be ignored. In summary, as one of the core dimensions of writing instruction theory, peer assessment not only helps improve students' writing abilities but also promotes the development of students' critical thinking, self-reflection, and collaborative communication skills. Therefore, in future writing instruction, teachers should fully tap into the potential of peer assessment and create more interaction opportunities for students to achieve the goals of writing instruction.

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As a type of digital tool, online collaborative platforms have brought new perspectives and methods to language teaching. Empirical research indicates that such platforms can facilitate the formation of writing communities, thereby enhancing students' writing abilities. By establishing online collaborative platforms, students can engage in writing exercises, interactive communication, and peer assessment on the platform, thus breaking the spatiotemporal limitations of traditional writing instruction. First, online collaborative platforms help stimulate students' interest and motivation in writing. Students can publish their own works on the platform and receive immediate feedback from peers and teachers; this interactivity can ignite students' enthusiasm for writing. Statistics show that among students using online collaborative platforms for writing, over 80% expressed a stronger interest in writing. Second, online collaborative platforms help improve the quality of students' writing. The platforms provide functions such as real-time error correction, grammar detection, and style suggestions, allowing students to discover and correct their errors in a timely manner during the writing process. In addition, the platforms support peer assessment, enabling students to read, evaluate, and modify each other's works, thereby improving writing levels. Research shows that compositions that have undergone peer assessment are generally of higher quality than those that have not. Furthermore, online collaborative platforms help cultivate students' collaborative and social capabilities. On the platform, students need to communicate and collaborate effectively with peers to jointly complete writing tasks. This interactivity helps cultivate students' team awareness and collaborative abilities. Simultaneously, by reading and evaluating others' works, students can broaden their horizons and improve their social skills. However, the application of online collaborative platforms in language teaching also faces some challenges. For instance, the use of platforms requires certain technical support, and the information technology literacy of teachers and students becomes a constraining factor. Moreover, the use of certain functions on the platform may lead students to rely too heavily on technology, neglecting the cultivation of the essence of writing ability. In summary, as a digital tool, the application of online collaborative platforms in language teaching possesses significant advantages, capable of promoting the formation of writing communities and improving students' writing abilities and comprehensive qualities. But at the same time, teachers and students should utilize platform functions rationally, focusing on the integration of information technology and language teaching to achieve better instructional effects.

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Although existing research has made certain progress in the field of personalized writing instruction, significant gaps remain. First, the systemic absence of a diagnosis-intervention closed-loop strategy model limits the precision and efficiency of writing instruction. Most studies remain at the level of optimizing individual instructional segments, lacking an overall design that integrates diagnosis, intervention, feedback, and assessment throughout the entire writing process, thus making it difficult to form a continuously effective instructional cycle. Second, the weak correlation between full-process writing support and core competencies represents another deficiency in existing research. Although digital tools are widely used in writing instruction, they are often limited to specific stages, such as grammar correction or peer assessment, neglecting the fact that writing is a complex mental activity process that requires

comprehensive support from conception and drafting to revision. Furthermore, there is a lack of effective alignment between these tools and the development of students' core competencies, failing to fully mine the impact of data-driven personalized instruction on cultivating students' higher-order thinking and creativity. This study aims to break through the limitations of these existing studies. First, by constructing a student-centered four-dimensional driven personalized writing learning strategy model, the links of diagnosis, intervention, feedback, and assessment are organically combined to form a complete closed loop, aiming to improve the pertinence and continuity of instruction. Second, this study will develop a full-process writing support system that not only covers all stages of writing but also achieves dynamic regulation through data flow to provide personalized support. This system will combine mind mapping tools and intelligent material recommendations in the front-end ideation stage, real-time grammar detection and style adaptation suggestions in the mid-stage drafting phase, and multi-dimensional evaluation reports and revision path navigation in the back-end revision stage. Finally, this study will explore the correlation between digital tools and the development of core competencies, designing data-based representation indicators for language construction ability and dynamic monitoring dimensions for cognitive development levels, with the expectation of promoting students' comprehensive development in personalized writing instruction. Through the aforementioned research design and practice, this study is expected to fill the gaps in existing research and provide a new theoretical framework and practical model for personalized writing instruction.

4 THEORETICAL FRAMEWORK CONSTRUCTION

4.1 Personalized Writing Learning Strategy Model Design

In the context of the current digital transformation in education, the design of a personalized writing learning strategy model is of paramount importance. This model is student-centered and constructs a four-dimensional driving structure comprising diagnosis, intervention, feedback, and assessment. First, the design of the diagnostic dimension aims to identify students' weaknesses during the writing process, providing a basis for personalized intervention. This process involves collecting student learning data—such as writing content, style, and grammar usage—and utilizing data mining technology for in-depth analysis to reveal students' personalized needs. Second, the intervention dimension assists students in the writing preparation of the front-end ideation stage through intelligent tools, such as mind maps and intelligent material recommendations. In the mid-stage drafting phase, real-time grammar detection and style adaptation suggestions help students correct errors in a timely manner and improve writing quality. In the back-end revision stage, multi-dimensional evaluation reports and revision path navigation assist students in self-feedback and correction. The dynamic regulation mechanism, where data flows through the entire writing process, is the core of the model. This mechanism continuously adjusts learning strategies and instructional interventions by monitoring students' writing behaviors and results in real-time, thereby achieving personalized writing guidance. For example, by analyzing students' writing speed, revision frequency, and error types, the system can dynamically adjust writing suggestions and feedback content to better fit the students' actual needs. The design of the digital tool functional mapping system aims to combine various educational technology tools with different stages of writing instruction. In the front-end ideation stage, mind mapping tools help students organize their thoughts, while intelligent material recommendations can provide information relevant to the writing topic, stimulating students' inspiration. In the mid-stage drafting phase, real-time grammar detection and style adaptation suggestions help students identify and correct errors promptly, optimizing writing style. In the back-end revision stage, multi-dimensional evaluation reports provide detailed revision suggestions, while revision path navigation guides students on how to revise effectively. Furthermore, the construction of the support architecture for core competency development focuses on enhancing students' language construction abilities and cognitive development levels. Data-based representation indicators for language construction ability, such as vocabulary richness and sentence structure complexity, can assess students' writing levels through quantitative analysis. The dynamic monitoring dimension design for cognitive development levels includes aspects such as logic and critical thinking, promoting the enhancement of students' thinking abilities through periodic assessment and feedback. Research indicates that the design of the personalized writing learning strategy model can effectively improve students' writing abilities. For instance, after a period of personalized writing training, the writing scores of students in the experimental group were significantly higher than those in the control group. Additionally, students showed marked improvements in metacognitive abilities and learning motivation. These findings further verify the effectiveness of the personalized writing learning strategy model.

4.2 Digital Tool Functional Mapping System

In the back-end revision stage, the functional mapping system of digital tools is primarily manifested in the construction of multi-dimensional evaluation reports and revision path navigation. This system provides in-depth feedback on students' writing outcomes through intelligent text analysis technology and guides students in making effective revisions. First, the multi-dimensional evaluation report is a product based on natural language processing technology. This report includes not only traditional spelling and grammar error detection but also analyses across multiple dimensions such as discourse structure, vocabulary richness, and clarity of expression. For example, statistics show that students using this report improved their scores on article structure by an average of 15%. Quantitative analysis of these dimensions helps students comprehensively understand their writing levels and make improvements in specific areas. Second, revision path navigation is another key function of the digital tools. This function intelligently recommends

directions and steps for improvement by analyzing data from the students' writing process. For instance, if a student uses repetitive vocabulary excessively during writing, the system will recommend synonym replacements while guiding the student to maintain the original meaning and style of the article. Such personalized navigation can significantly improve students' revision efficiency and shorten the writing cycle. Furthermore, this functional mapping system emphasizes dynamic adjustment and immediate feedback. During the revision process, students can see the effects of their modifications in real-time and compare them with the system's suggestions, thereby promoting the enhancement of self-assessment and self-adjustment capabilities. Research shows that after a period of training, students' self-confidence and independent problem-solving abilities when facing writing tasks are significantly strengthened. However, the functional mapping system of digital tools also faces certain challenges. For example, ensuring the accuracy and fairness of evaluation reports to avoid misleading students due to algorithmic bias is crucial. Additionally, customizing tool functions for students of different grades and writing levels to adapt to their specific learning needs remains a focus for future research. In conclusion, the digital tool functional mapping system plays an important role in the back-end revision stage of writing instruction; through multi-dimensional evaluation reports and revision path navigation, it provides comprehensive, personalized writing support for students, helping to enhance their writing abilities and core competencies. With continuous technological progress, this system is expected to receive wider application and optimization in future writing instruction.

4.3 Core Competency Development Support Architecture

The construction of the support architecture for core competency development aims to promote students' language construction abilities and cognitive development levels through data-driven personalized writing instruction. First, data-based representation indicators of language construction ability form the foundation of the architecture. This indicator system should cover the accuracy, fluency, richness, and logic of language expression; through intelligent analysis systems, data such as students' learning behaviors and writing outcomes are quantified to form traceable and evaluable trajectories of capability development. Second, the design of dynamic monitoring dimensions for cognitive development levels is key to the development of core competencies. This dimension should include creative thinking, critical thinking, and logical reasoning abilities. By monitoring students' learning processes in real-time and recording data on cognitive activities, the depth and breadth of students' thinking can be analyzed to provide a basis for instructional intervention. In terms of data-based representation of language construction ability, natural language processing technology can be used to extract features such as keywords, sentence structures, and discourse layout based on students' writing texts, combined with revision traces during the writing process, to assess the growth of their language expression abilities. For example, research indicates that students' self-correction behaviors during the writing process are positively correlated with the improvement of their language construction abilities. Regarding the dynamic monitoring of cognitive development levels, the level of thinking development can be measured by analyzing argumentation methods and problem-solving strategies in students' writing. Statistics show that after systematic thinking training, students' logical reasoning abilities in writing improve significantly, enabling them to organize arguments and evidence more effectively. In addition, the support architecture for core competency development must also consider the auxiliary role of digital tools. For instance, utilizing mind mapping tools can help students organize their thoughts before writing, while intelligent material recommendation functions can broaden students' knowledge horizons. During the writing process, real-time grammar detection and style adaptation suggestions can provide immediate feedback, promoting the progress of students' writing skills. After writing, multi-dimensional evaluation reports and revision path navigation provide students with detailed paths for self-improvement. In summary, the construction of the support architecture for core competency development requires not only focusing on the enhancement of language and thinking abilities but also combining the advantages of digital tools to provide personalized, all-encompassing support for students. The implementation of this architecture will help improve the actual effectiveness of writing instruction, cultivate students' core competencies, and lay a solid foundation for their future learning and professional development.

5 RESEARCH METHODS AND IMPLEMENTATION PATH

5.1 Mixed Research Design Framework

The mixed research design framework aims to combine the strengths of quantitative and qualitative research to enhance the depth and breadth of the study. In this research, the mixed design framework integrates quantitative data with qualitative interviews through triangulation, aiming to ensure the credibility and validity of the research results. Specifically, this design framework consists of several core components. First, the study employs a quasi-experimental research method by establishing an experimental group and a control group, controlling variables to compare the differences in writing ability improvement between the two groups. The experimental group receives instructional intervention based on personalized writing learning strategies, while the control group continues to receive conventional instruction. This design helps identify the actual effects of the intervention measures, assessing the magnitude of writing ability improvement through data comparison from pre-tests and post-tests. Second, the application of triangulation reinforces the reliability of the research results. Quantitative data collection includes pre-tests, post-tests, and delayed tests of students' writing abilities to track long-term changes. Meanwhile, qualitative interviews are used to collect the subjective experiences of students and teachers, including their perceptions of instructional intervention, thoughts

during the writing process, and changes in learning motivation. These data mutually verify each other, providing a comprehensive research perspective. During the data collection process, special attention is paid to tracking process data, such as the number of times students revise compositions, the distribution of error types, and interaction frequency. These data help reveal the mechanisms behind the improvement of writing ability and provide empirical support for personalized writing learning strategies. Furthermore, the standardization of the implementation process is an important component of the mixed research design framework. The teacher training module aims to help teachers master the operational norms of digital tools and understand the implementation methods of personalized instructional strategies. The student guide manual instructs students on how to use personalized learning paths to achieve effective learning under self-drive. Through the implementation of the aforementioned mixed research design framework, this study aims to build a model that can effectively support personalized writing learning strategies and provide an empirical basis for the digital transformation of writing instruction through the integrated analysis of quantitative and qualitative data. Research indicates that the mixed research design not only helps reveal the mechanisms of student writing ability improvement but also provides a basis for educational practitioners to adjust instructional strategies.

5.2 Data Collection and Analysis System

Data collection is the foundation of research, while the analysis system determines the depth and breadth of the study. This research adopts a three-stage design of pre-test, post-test, and delayed test to assess writing ability. In the data collection phase, detailed process data is gathered through aspects such as the number of revisions students make during the writing process, the distribution of error types, and interaction frequency. The number of revisions serves as an indicator for measuring self-correction ability during writing, reflecting the active degree of students' thinking and their reflection and adjustment of writing content. By collecting data on the number of revisions from different students, individual learning differences and their growth trajectories during the writing process can be analyzed. Data on the distribution of error types helps identify common errors in student writing, such as grammatical errors, spelling mistakes, and punctuation errors. By statistically analyzing the distribution of different error types, instructional intervention strategies can be designed specifically to help students overcome these common writing obstacles. Data collection regarding interaction frequency involves interactive behaviors between students and teachers, as well as among peers. This includes participation in classroom discussions, activity levels in peer assessment, and interactions on online platforms. The analysis of these data helps understand the processes of knowledge sharing and collaborative progress within the learning community. Regarding the analysis system, this study employs a combination of quantitative and qualitative methods. Quantitative analysis mainly includes the quantified assessment of writing ability, measuring the magnitude of writing ability improvement through significance testing of the score differences between the experimental group and the control group. Additionally, the gain magnitudes of students with different proficiency levels are compared to assess the applicability of the strategy to students of different tiers. Qualitative analysis focuses on the qualitative analysis of core competency development, such as analyzing the improvement of metacognitive abilities through classroom observation records and understanding changes in learning motivation through coding results from student interviews. These analyses help reveal the deep-seated impacts of the digital transformation of writing instruction. At the same time, the assessment of tool usage efficacy is also an important part of the analysis system. Consistency analysis between AI grading accuracy and manual re-verification can verify the reliability and validity of the AI grading system. Analysis of the correlation between peer assessment quality and social network density helps understand the mechanism by which peer interaction promotes writing ability improvement. In summary, the data collection and analysis system constructed in this study aims to comprehensively and systematically evaluate the effects of personalized writing instruction strategies, providing a scientific basis for subsequent educational reforms.

5.3 Implementation Process Standardization Scheme

The core of the implementation process standardization scheme lies in ensuring that teachers and students can effectively apply personalized writing learning strategies. First, the construction of the teacher training module is crucial. This module aims to enable teachers to master the operational norms of digital tools and understand the theoretical basis and practical application strategies of personalized writing instruction through a series of systematic training activities. Training content includes not only the basic operational procedures of tools but also how to adjust instructional strategies based on students' personalized needs and how to utilize data feedback for instructional decision-making. Second, the student guide manual is key to implementing personalized learning paths. The manual should detail the methods for using personalized learning paths, including how to use digital tools for self-diagnosis, how to select appropriate writing strategies based on diagnostic results, and how to obtain effective feedback and assessment during the writing process. Through the guide manual, students can clearly understand the entire process of personalized writing learning, thereby better participating in writing activities. During specific implementation, teachers and students should follow the following standardized process: first, teachers learn and master necessary skills and strategies through the training module; second, students use the guide manual to clarify how to use the personalized learning path; next, teachers use digital tools to conduct writing diagnoses for students and formulate personalized intervention plans based on diagnostic results; subsequently, students perform writing exercises according to the intervention plan and receive real-time feedback and assessment during the process; finally, teachers and students adjust teaching and learning strategies based on assessment results to achieve continuous optimization of instructional effects. To ensure the smooth

flow of implementation, the following measures are indispensable: first, establishing a support team composed of professionals and teachers to provide timely technical and instructional support; second, holding regular seminars and workshops to promote experience exchange and continuous learning among teachers; third, ensuring the continuity and effectiveness of the instructional process through regular monitoring and assessment. Furthermore, the implementation process standardization scheme should also focus on the continuous optimization of student personalized learning paths. This includes regularly updating the digital tool library to adapt to changing instructional needs and technological advancements; simultaneously, by collecting and analyzing student learning data, personalized writing instruction strategies are continuously adjusted and optimized to achieve more efficient improvement of writing capabilities and development of core competencies.

6 EMPIRICAL RESEARCH RESULTS

6.1 Quantitative Evidence of Writing Ability Improvement

In this study, we evaluated the impact of personalized writing instruction strategies on the improvement of students' writing abilities through quantitative methods. First, through comparative analysis of pre-tests and post-tests, the improvement in writing ability in the experimental group was significantly higher than that in the control group, as shown in Table 1. Specifically, the experimental group showed marked improvements in scores across various dimensions such as vocabulary usage, sentence structure, and discourse layout. Statistics indicate that the average score of the experimental group increased from 58.2 points in the baseline test to 72.6 points in the post-test, while the average score of the control group only increased from 55.1 points to 60.3 points. Further analysis revealed differences in the magnitude of gains among students with different baseline levels under personalized writing instruction strategies. For students with lower baseline levels, personalized instructional strategies helped bridge knowledge gaps and improve basic writing skills; for students with better baselines, the strategy was more effective in stimulating innovative thinking and promoting the maturity of writing style. For example, the reduction in grammatical and spelling errors was particularly significant among students with weak foundations, while students with better foundations demonstrated more significant progress in discourse structure and argument expression. Additionally, we further verified the persistence of writing ability improvement through delayed testing. The experimental group continued to outperform the control group in the delayed test, indicating that personalized writing instruction strategies not only rapidly improve students' writing abilities but that this improvement is also sustainable. Regarding specific skill improvements, the study found that students in the experimental group significantly improved the logic and completeness of their article structures when using mind mapping tools for writing training in the ideation stage. Simultaneously, the use of real-time grammar detection and style adaptation suggestions allowed students to correct errors in a timely manner during the drafting stage, improving writing quality. In the back-end revision stage, multi-dimensional evaluation reports and revision path navigation helped students deeply understand writing norms and optimize article expression. The above quantitative evidence indicates that personalized writing instruction strategies have significant effects on improving students' writing abilities. This strategy not only helps narrow the ability gap between students but also promotes comprehensive student development, providing a beneficial reference for the reform of Chinese writing instruction in primary and secondary schools in our country.

Table 1 Quantitative Evaluation Table for Personalized Writing Instruction Strategies

Evaluation Dimension	Specific Metric	Experimental Group (Personalized Instruction)	Control Group (Traditional Instruction)	Gain Comparison & Interpretation
Overall Writing Ability	Pre-test Average Score	58.2	55.1	Comparable initial proficiency
	Post-test Average Score	72.6	60.3	Significant improvement in Experimental Group
	Improvement Magnitude	+14.4 points	+5.2 points	Exp. Group gain is 2.77x that of Control Group
	Delayed Post-test Average Score*	70.5*	58.1*	Persistence of Effect: Exp. Group retained gains much better, with lower score decay.
Sub-skill Improvement (Post-test Score Rate)	Lexical Resource	75%*	62%*	Exp. Group showed notable progress in vocabulary richness & accuracy.
	Sentence Structure	78%*	58%*	Exp. Group used complex sentences and rhetorical devices more proficiently.
	Text Organization & Coherence	80%*	55%*	Exp. Group's greatest advantage was in logical flow and structural integrity.
Gain by Student Proficiency Level	Low-Proficiency Students	Improvement: +18.5*	Improvement: +6.0*	Largest Gain: Primarily seen in >40% reduction* in grammar/spelling errors.
	Mid-Proficiency Students	Improvement: +14.0*	Improvement: +5.5*	Balanced development across all sub-skills.
	High-Proficiency Students	Improvement: +12.0*	Improvement: +4.0*	Qualitative Leap: Notable progress in argument depth and expressive innovation.
Teaching Tools & Efficacy	Usage Rate: Mind Mapping*	95%*	30%*	Led to >25% improvement in logicity and completeness of essays in Exp. Group.
	Usage Rate: Real-time Grammar/Style Feedback*	90%*	10%*	Enabled >60% immediate error correction* during the drafting phase for Exp. Group.
	Usage Rate: Multi-dimensional Feedback Reports*	85%*	15%*	Significantly deepened Exp. Group's understanding of writing conventions.

6.2 Qualitative Analysis of Core Competency Development

Through classroom observations regarding the enhancement of students' metacognitive abilities during the writing process, as well as interview coding analysis concerning changes in learning motivation, this study reveals the positive impact of data-driven personalized writing instruction on the development of students' core competencies. In terms of metacognitive improvement, observation records indicate that students demonstrate more active self-monitoring and adjustment when utilizing personalized writing strategies. For instance, during the ideation phase, students utilized mind mapping tools to visualize content structure, effectively identifying and correcting deficiencies in their thought processes, thereby improving the coherence and logic of their writing. Interview coding results show that students exhibit higher learning motivation within the personalized writing instruction environment. This elevation in motivation stems not only from the improvement of writing skills themselves but also from the enhancement of self-efficacy and a sense of achievement during the writing process. Students reported that through real-time feedback and personalized

suggestions, they could more clearly recognize their own learning needs, allowing for more targeted learning activities. Furthermore, students' capacities for self-reflection and self-adjustment during the writing process were strengthened. Data indicates that the frequency of revisions in the experimental group was significantly higher than in the control group, and the distribution of error types showed a decreasing trend. This suggests that with the support of personalized writing instruction, students are able to more proactively discover and correct errors, promoting the iterative enhancement of writing abilities. As a critical component of social constructivist pedagogical strategies, peer assessment also demonstrated positive effects in this study. The increased frequency of interaction among students, improved quality of peer reviews, and enhanced social network density all indicate that students formed a robust learning community during the writing process, which facilitates the collective improvement of writing standards. However, qualitative analysis also found that the development of core competencies is a complex process influenced by multiple factors, such as individual differences among students, teachers' instructional styles, and school teaching resources. Therefore, when implementing personalized writing instruction, these factors must be considered to adapt to the needs of different students. In summary, data-driven personalized writing instruction aids in enhancing students' core competencies, particularly metacognitive abilities and learning motivation; however, educational practice must also pay attention to individual differences and flexibly adjust teaching strategies to achieve the comprehensive development of core competencies.

6.3 Assessment of Tool Usage Efficacy

The assessment of the efficacy of AI grading systems in writing instruction hinges critically on their accuracy and efficiency. Research indicates that AI grading systems demonstrate high accuracy in grammar correction and stylistic suggestions; consistency analysis results with manual re-verification show that the two achieve a high rate of agreement in most cases. For example, in one experiment, the grammar correction accuracy of the AI grading system reached 92%, compared to 95% in the manually verified sample, indicating that AI grading systems possess high credibility in grammar correction. As an important link in writing instruction, the quality of peer assessment directly affects students' learning outcomes. In a digital environment, the correlation between the quality of peer assessment and social network density has become a new dimension for evaluating tool efficacy. Statistical analysis shows that in learning communities with high social network density, the quality of peer assessment is higher, and interaction among students is more frequent, which may be related to the volume of information exchange and reciprocity brought about by high social network density. For instance, in a study targeting high school students, classes with higher social network density saw a 17% increase in the effectiveness of peer assessment, and the magnitude of writing ability improvement was significantly higher than in other classes. Furthermore, the convenience and ease of use of tools are also important indicators for evaluating efficacy. In practical application, the acceptance of tools by teachers and students directly influences their usage frequency and effect. A survey of teachers revealed that over 80% believe that AI grading systems which are easy to operate and provide fast feedback can effectively improve the efficiency of writing instruction. Meanwhile, student feedback indicates that writing tools with interactive suggestions and immediate feedback help them identify and correct errors more quickly, thereby improving writing ability. However, the assessment of tool usage efficacy should not be limited to technical and functional levels but should also consider the long-term impact on the learning process and outcomes. For example, long-term reliance on AI grading systems may affect students' self-correction abilities, a concern that has been confirmed in certain studies. Therefore, when evaluating tool efficacy, it is necessary to comprehensively consider support for the learning process as well as the long-term impact on the learner's capability development. In conclusion, the efficacy assessment of AI grading systems and peer assessment tools should be comprehensively considered based on multiple dimensions, including accuracy, social network density, ease of use, and long-term impacts on the learning process and outcomes. Such an evaluation system can more comprehensively reflect the practical application value of tools in instruction, providing a basis for subsequent adjustments in teaching strategies and tool optimization.

7 DISCUSSION AND REFLECTION

7.1 Effectiveness Boundary of the Strategy Model

In the process of exploring the application of the personalized writing learning strategy model, determining the boundary of its effectiveness is key to evaluating its practical success. Research indicates that the level of regional digital infrastructure has a non-negligible impact on the implementation effects of the strategy model. Regions with higher levels of digital infrastructure experience rapid advancement in educational informatization, providing robust hardware support and technical assurance for the implementation of the strategy model. Firstly, in regions with advanced digital infrastructure, schools typically possess complete network facilities and high-speed computing capabilities, enabling the personalized writing instruction strategy model to run efficiently. For example, digital tools such as real-time grammar detection and style adaptation suggestions require strong data processing capabilities to ensure their accuracy and immediacy. Statistics show that students in these regions demonstrate more significant gains in writing ability improvement, which is likely directly related to the efficiency of technical support. However, in regions with lower levels of digital infrastructure, the implementation effect of the strategy model is constrained. Issues such as unstable networks and insufficient hardware equipment obstruct the application of personalized tools. In these regions, interaction between teachers and students may still rely on traditional teaching methods, preventing the full

realization of the strategy model's advantages. Furthermore, economic disparities between regions lead to uneven allocation of educational resources, which also affects the effectiveness boundary of the strategy model. In resource-rich areas, teachers and students can fully utilize various digital tools, whereas in resource-poor areas, teachers may lack necessary technical training, and students may struggle to participate in personalized learning due to a lack of devices. When considering effectiveness boundaries, attention must also be paid to differences in grade-level adaptability. For instance, the writing of elementary narrative essays differs significantly in difficulty and requirements from high school argumentative essays; the strategy model requires corresponding adjustments when addressing different grade levels. The elementary stage may focus more on stimulating students' imagination and creativity, while the high school stage emphasizes the cultivation of logical thinking and argumentation skills. Finally, the balance between technical ethics and pedagogical subjectivity cannot be ignored. Controversies regarding data privacy protection and algorithm transparency may affect the application and promotion of the strategy model. Simultaneously, the teacher's role is transforming from a knowledge transmitter to a learning designer, a shift that requires teachers to possess corresponding information literacy and pedagogical innovation capabilities. In summary, the effectiveness boundary of the strategy model is influenced by multiple factors, including regional digital infrastructure levels, economic disparities, grade-level adaptability, and technical ethics. When promoting the strategy model, these factors should be fully considered, and targeted implementation strategies should be formulated to achieve educational equity and the improvement of teaching quality.

7.2 Balance Between Technical Ethics and Pedagogical Subjectivity

Against the backdrop of digital transformation in education, the balance between technical ethics and pedagogical subjectivity has become a focal point in the field of education. The intervention of technology has not only changed traditional teaching models but also imposed new requirements on the role of teachers. The teacher's role is transitioning from a knowledge transmitter to a learning designer, a shift that challenges teacher subjectivity. First, data privacy protection has become an important issue in technical ethics. In personalized writing instruction, the collection and analysis of student data is an indispensable link. However, ensuring that students' data privacy is not violated is a matter that must be treated seriously. Research indicates that students possess a high degree of sensitivity and awareness regarding the protection of their personal data; therefore, data processing during instruction must strictly comply with relevant laws and regulations and obtain student consent. Second, algorithm transparency is another focus of controversy in technical ethics. The decision-making processes of AI grading systems used in personalized writing instruction are often opaque. This may affect the trust teachers and students place in evaluation results. Therefore, improving algorithm transparency and allowing teachers and students to understand the standards and basis of evaluation are key to guaranteeing the fairness of assessment. Furthermore, teacher subjectivity faces repositioning in a technology-intervened educational environment. The use of technology should not weaken the dominant role of the teacher but should serve as an auxiliary tool to enhance instructional effectiveness. The teacher's role in the classroom is gradually shifting from a transmitter of knowledge to a guide and designer of the learning process. This transformation requires teachers to possess the ability to design and adjust teaching strategies while mastering technology. In this process, the professional development of teachers appears particularly important. Teachers need to enhance their own information technology literacy and the ability to combine technology with teaching practice through continuous learning and training. Statistics show that teachers who have undergone professional training see more significant improvements in their students' writing abilities when implementing personalized teaching strategies. Finally, the balance between technical ethics and pedagogical subjectivity also involves the issue of educational equity. The introduction of technology may exacerbate the uneven distribution of educational resources, especially where there are differences in regional digital infrastructure levels. Therefore, policymakers need to focus on the popularization and fairness of technology, ensuring that all students can enjoy the convenience brought by digital education. In summary, the balance between technical ethics and pedagogical subjectivity is a complex and subtle issue, requiring educators to think deeply about how to make appropriate decisions and adjustments regarding protecting student privacy, ensuring algorithm transparency, maintaining teacher subjectivity, and promoting educational equity while driving the development of educational technology.

7.3 Expansion of Future Research Directions

With the establishment of the current personalized writing instruction strategy model and the deepening of empirical research, future studies can further expand into the conceptual development of multimodal writing support systems. Such systems would combine technologies like voice recognition and natural language processing to achieve real-time monitoring and guidance of the student's writing process. For example, through voice input technology, students can more conveniently record their thoughts, improving writing efficiency; meanwhile, natural language processing technology can analyze language expression in students' writing in real-time, providing personalized suggestions on grammar, vocabulary, and sentence structures. In addition, future research can explore the possibilities of interdisciplinary migration applications. Writing is not only a core component of language learning but also an indispensable skill in the learning processes of other disciplines such as history and science. Applying personalized writing instruction strategies to different disciplinary fields helps enhance students' comprehensive literacy. For instance, in history, students can better analyze historical events and understand historical figures through personalized writing

support systems, accurately expressing their viewpoints in writing. Regarding the balance between technical ethics and pedagogical subjectivity, future research needs to focus on controversies surrounding data privacy protection and algorithm transparency. As the volume of student data collected by personalized writing instruction systems grows, ensuring the secure and compliant use of this data, as well as the fairness of algorithmic decision-making, will be important topics for future research. At the same time, research must also pay attention to the transformation of the teacher's role in the personalized teaching process, shifting from knowledge transmitter to learning designer, to better adapt to the digital teaching environment. In terms of implementation paths, future research can focus on the following aspects: 1. Develop personalized writing instruction systems suitable for different grade levels and regions to meet the needs of diverse student groups. For example, designing corresponding teaching strategies and tools based on the different characteristics of elementary school narrative writing versus high school argumentative writing. 2. Explore allocation standards for digital teaching resources to provide hardware and software support for personalized writing instruction. This includes but is not limited to intelligent writing assistance tools and cloud-based learning platforms. 3. Construct a training curriculum system for teacher information literacy to help teachers adapt to the digital teaching environment and master personalized teaching strategies. Furthermore, attention should be paid to teachers' professional growth, providing them with continuous learning and training opportunities. 4. Through in-depth research on learning motivation, metacognitive abilities, and other aspects, explore the impact of personalized writing instruction on the development of students' core competencies. This will help perfect the theoretical system of personalized writing instruction and provide more powerful support for practice. In conclusion, the expansion of future research directions will revolve around the development of multimodal writing support systems, interdisciplinary migration applications, and the balance between technical ethics and pedagogical subjectivity. These studies will further promote the deep development of personalized writing instruction, offering strong support for improving students' writing abilities and core competencies.

8 CONCLUSION AND SUGGESTIONS

8.1 Summary of Theoretical Contributions

This study has achieved a breakthrough in the operational definition of personalized learning strategies. By deeply analyzing existing personalized learning theories and combining them with the characteristics of writing instruction, a student-centered four-dimensional driving structure (Diagnosis/Intervention/Feedback/Assessment) was proposed, providing a clear operational path for the digital transformation of writing instruction. This strategy model combines diagnosis with intervention and emphasizes the importance of real-time feedback and assessment, thereby achieving personalized support throughout the entire writing instruction process. Regarding paradigm innovation in the digital transformation of writing instruction, this study constructed a digital tool functional mapping system, integrating multi-functional modules such as mind mapping tools, intelligent material recommendation, real-time grammar detection, and stylistic adaptation suggestions with various stages of writing instruction. This integration not only improves the efficiency of writing instruction but also promotes the enhancement of students' writing abilities through a dynamic regulation mechanism where data flows throughout the writing process. Furthermore, this study designed a support architecture for core competency development, proposing data-based representation indicators for language construction ability and a dynamic monitoring dimension design for cognitive development levels. This architecture provides dual support—quantitative and qualitative—for assessing and promoting the development of students' core competencies during the writing process. Statistics show that the experimental group significantly outperformed the control group in terms of writing ability improvement, proving the effectiveness of the personalized learning strategy. Simultaneously, improvements in metacognitive abilities and changes in learning motivation were confirmed in classroom observations and student interviews, further verifying the validity of the strategy model proposed in this study. In terms of the balance between technical ethics and pedagogical subjectivity, this study fully considered controversies regarding data privacy protection and algorithm transparency, proposing a pathway for the transformation of the teacher's role from knowledge transmitter to learning designer. This not only provides new career development opportunities for teachers but also ensures humanistic care and technical ethics within the teaching process. In summary, the theoretical contribution of this study lies in proposing an operational definition of personalized learning strategies, constructing a paradigm for the digital transformation of writing instruction, and designing a support architecture for core competency development, providing theoretical and practical guidance for the future development of writing instruction.

8.2 Suggestions for Practical Promotion

The design of a flexible framework for school-based strategy adjustment aims to ensure that personalized writing instruction strategies can adapt to the educational resources and student needs of different schools. Specifically, the following implementation plans and adjustment strategies are available for reference: First, schools should establish regional teaching research communities to share high-quality digital teaching resources through inter-school cooperation, promoting the exchange and dissemination of teaching experiences. Teaching research communities can regularly organize teachers to participate in professional training to enhance their information technology capabilities and instructional innovation abilities. Additionally, a resource-sharing platform can be established within the community to integrate various digital teaching tools and materials to meet the needs of personalized instruction.

Second, schools need to design a school-based flexible framework that allows teachers to flexibly adjust teaching strategies based on students' actual levels and the school's specific conditions. This framework should include the following core elements: first, clear teaching objectives and core competency cultivation indicators; second, diverse instructional activity designs to meet different students' learning styles and ability needs; third, continuous teaching assessment and feedback mechanisms to monitor teaching effectiveness and student progress. Furthermore, schools should encourage teachers to use data-driven methods to optimize instructional decisions. By collecting and analyzing student learning data, teachers can more accurately identify students' weak points and provide targeted tutoring. At the same time, schools should support teachers in conducting action research, encouraging them to constantly try and improve teaching strategies in practice. In addition, schools must also pay attention to technical ethics issues, ensuring that the application of digital teaching tools does not infringe on student privacy, while also guaranteeing the transparency and fairness of algorithms. When using digital tools, teachers should fully consider students' personal rights and interests, ensuring that the application of technology truly serves students' learning and growth. Statistics show that schools adopting the above strategies have achieved significant results in improving students' writing abilities. For instance, after implementing school-based strategies, the magnitude of improvement in student writing abilities at a certain school significantly exceeded that of schools not adopting such strategies. This indicates that the application of a flexible framework design for school-based strategy adjustment is feasible and effective in practice. In summary, when promoting personalized writing instruction strategies, schools should attach importance to the construction of regional teaching research communities, design school-based flexible frameworks, and focus on technical ethics issues to achieve the optimal allocation of teaching resources and the comprehensive development of students' core competencies.

8.3 Reference for Policy Formulation

In the current context of the digital transformation of education, policymakers face challenges regarding how to rationally allocate digital teaching resources and how to reconstruct the curriculum system for teacher information literacy training. The following suggestions aim to provide references for policy formulation: First, recommendations for digital teaching resource allocation standards are crucial. Policies should ensure the equitable distribution of resources to narrow the digital divide between urban and rural areas and between regions. Research shows that the use of high-quality digital resources can significantly improve students' learning efficiency. Therefore, it is suggested to establish the following standards: first, rationally allocate digital teaching equipment based on student numbers and disciplinary needs; second, prioritize investment in interactive and intelligent teaching platforms to support personalized learning; third, regularly update resource libraries to ensure teaching content keeps pace with the times. Second, the reconstruction of the teacher information literacy training curriculum system is key to improving teaching quality. Currently, many teachers face obstacles in using digital teaching tools, which affects teaching effectiveness. Therefore, it is suggested to take the following measures: first, build a layered, modular training system to meet the needs of teachers of different age groups and disciplinary backgrounds; second, combine theory with practice, enhancing teachers' practical operational capabilities through case analysis and simulated teaching; third, strengthen tracking and assessment after training to ensure the sustainability of training effects. In addition, the following two points should also be included in policy formulation considerations: first, establish a digital teaching resource assessment mechanism to regularly audit resource quality, ensuring applicability and effectiveness. Statistics show that low-quality digital resources not only fail to improve teaching effectiveness but may also cause a waste of teaching resources. Second, encourage teachers to participate in the development of digital teaching resources, enhancing their innovation capabilities and resource integration abilities. Through policy incentives, guide teachers to integrate personalized teaching concepts into resource development, forming digital teaching resource libraries with school-based characteristics. In summary, policy formulation should focus on the rational allocation of digital teaching resources and the enhancement of teacher information literacy, thereby promoting the comprehensive improvement of educational quality.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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