Research on Personalized Cultivation Paths of Vocational College Students' Digital Literacy in the Artificial Intelligence Era

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ABSTRACT The in-depth application of artificial intelligence has reshaped vocational education and made digital literacy a key component of students' core competitiveness. Vocational colleges currently face prominent problems in digital-literacy cultivation, including large differences in students' basic foundations, homogenized training models, and single evaluation systems. Constructing a personalized cultivation path requires starting from learner characteristics, integrating intelligent technology empowerment, hierarchical and classified teaching, and dynamic evaluation and feedback, and forming a closed-loop mechanism of "diagnosis-design-implementation-evaluation." This paper analyzes the theoretical basis and core elements of digital literacy in vocational education, identifies current cultivation dilemmas , and proposes personalized training programs based on learner profiles. By diagnosing students' digital-competence baselines, customizing differentiated learning paths, and improving continuous feedback mechanisms, the proposed approach can enhance students' digital cognition, digital operation, and digital application capabilities. The study provides a practical reference for cultivating high-quality technical talents adapted to intelligent industrial environments.

INDEX TERMS artificial intelligence, vocational education, digital literacy, personalized cultivation, learner profile

I. INTRODUCTION

THE rapid development of new-generation information technologies such as artificial intelligence, big data, and cloud computing is profoundly changing the manufacturing landscape and fiber performance analysis, thereby reshaping social production and the demand for specialized vocational competence. As a basic literacy for citizens in the digital age, digital literacy has become an essential ability for vocational college students to adapt to future work and achieve lifelong development. Vocational education, as the main position for cultivating technical and skilled talents, undertakes the important mission of improving students' digital literacy. However, the group of vocational college students presents characteristics of diverse student sources, differentiated foundations, and varied development needs. The traditional "one-size-fits-all" training model is difficult to meet the needs of personalized growth.

II. THEORETICAL BASIS AND CORE ELEMENTS OF VOCATIONAL COLLEGE STUDENTS' DIGITAL LITERACY CULTIVATION

A. CONCEPT EVOLUTION AND FRAMEWORK COMPOSITION OF DIGITAL LITERACY

The current mainstream framework decomposes vocational digital literacy into three progressive levels: the digital cognition layer (understanding technical principles), the digital operation layer (standardized mastery and efficient application of tools), and the digital application layer (flexible integration of skills to solve vocational problems). The digital operation layer focuses on operational proficiency and standardization, such as skilled use of industry-specific software interfaces, standardized data input/output, and proficient operation of intelligent platforms [1], with assessment based on quantitative indicators including task completion efficiency, error rates, and operational standardization. The digital application layer emphasizes the ability to address complex practical issues, such as optimizing production processes through data analysis tools or designing digital solutions for professional scenarios, evaluated by problem-solving effectiveness, rationality of tool combination, and innovation of solutions. These three levels support each other and spiral upward, jointly forming the core competitiveness of students adapting to the intelligent era, as shown in Figure 1.

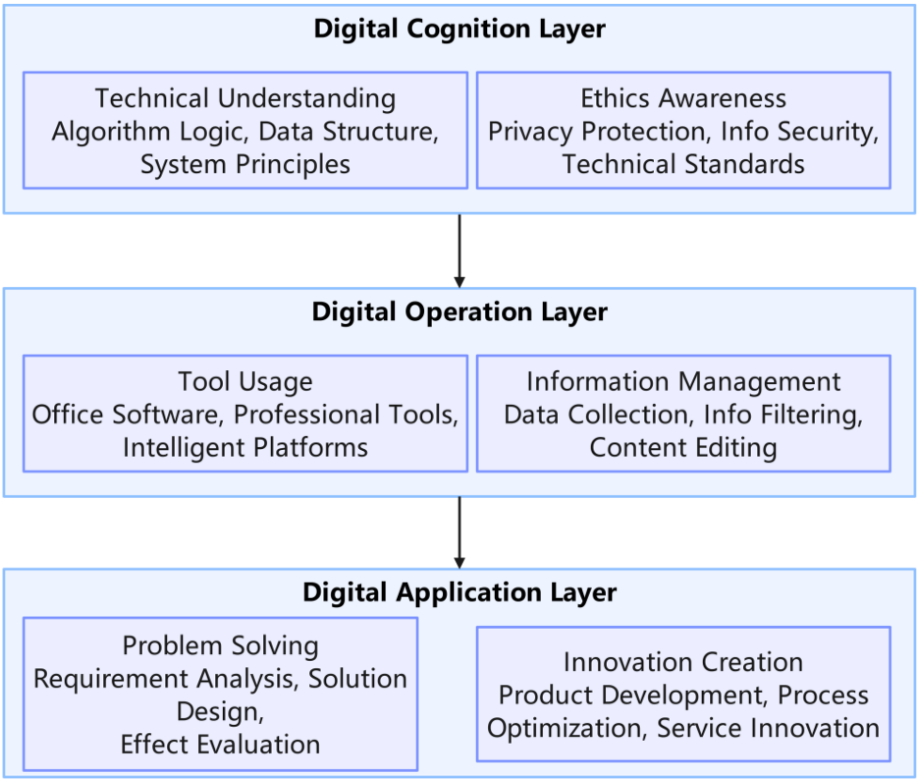

FIGURE 1. Vocational Digital Literacy Competency Framework

This framework reflects the progressive path of digital literacy from basic cognition to complex application, with the three levels supporting each other and spiraling upward. The digital cognition layer lays a theoretical foundation for subsequent development, the digital operation layer transforms cognition into practical skills, and the digital application layer reflects the comprehensive application level of literacy in real vocational scenarios. The operation and application layers are distinguished by independent assessment metrics: the former focuses on 'efficiency, accuracy, and standardization,' while the latter emphasizes 'problem-solving effect, tool integration capability, and innovation.'

B. APPLICABILITY ANALYSIS OF PERSONALIZED LEARNING THEORY

Personalized learning theory originates from the constructivist learning concept, emphasizing the provision of customized educational services according to differences in learners' characteristics. Gardner's multiple intelligences theory reveals that individuals have significant differences in intelligent dimensions such as logical-mathematical and visual-spatial intelligence, and a single teaching model is difficult to activate the dominant intelligence areas of all learners. The group of vocational college students presents characteristics of diverse student sources, differentiated knowledge foundations, and clear vocational orientation. Some students have strong practical operation ability but weak theoretical foundations, while others are good at logical reasoning but lack hands-on ability. Uniform training standards are likely to cause a dilemma where some students 'lack cognitive challenge' and others 'experience cognitive overload'. The development of artificial intelligence technology provides technical support for personalized learning. Through the collection of learning behavior data and intelligent algorithm analysis, it is possible to accurately identify learners' ability levels[2], cognitive styles, and development potential. The introduction of personalized learning mechanisms in vocational digital literacy cultivation requires the establishment of a learner profile system, the development of hierarchical teaching resources, and the design of flexible learning paths to transform theoretical guidance into operable teaching plans.

C. CHARACTERISTIC DIMENSIONS OF VOCATIONAL COLLEGE STUDENTS' DIGITAL LITERACY

Vocational college students' digital literacy presents three core characteristics: vocational orientation, developmental difference, and application practicality. Vocational orientation is reflected in that digital competence training must serve specific job requirements. Students majoring in intelligent manufacturing need to be proficient in using CAD modeling software and industrial data analysis platforms, while students majoring in e-commerce need to master live streaming technology and data marketing tools. This professional specificity requires training programs to closely align with the trend of industrial digital transformation[3]. Developmental differences stem from complex student source structures and uneven growth environments. There are significant gaps between urban and rural students in the frequency of contact with digital devices and the accumulation of online learning experience, leading to a polarization of digital literacy levels within classes. Application practicality emphasizes that digital literacy is a comprehensive quality that invokes multiple abilities to collaboratively solve complex problems in real vocational scenarios. Students need to learn comprehensive skills such as data collection and analysis, intelligent tool selection, and digital program design in simulated or real work scenarios. Therefore, the cultivation of vocational digital literacy must construct a progressive training chain of “theoretical cognition-skill training-situational application”, balancing unified standards and differentiated needs, as well as theoretical learning and practical application.

III. IDENTIFICATION OF DILEMMAS IN VOCATIONAL COLLEGE STUDENTS’ DIGITAL LITERACY CULTIVATION

A. CONTRADICTION BETWEEN STUDENTS’ INDIVIDUAL DIFFERENCES AND UNIFIED TRAINING MODELS

Currently, the cultivation of digital literacy in vocational colleges generally adopts a homogenized model with unified curriculum standards, unified teaching progress, and unified assessment methods. This model forms a sharp contradiction with the reality of significant individual differences among students. The student source structure is diversified, including fresh junior high school graduates, social recruits, and retired military personnel, with an age span of up to more than ten years and a huge gap in digital skills foundation. Urban student groups have been in contact with smartphones and computer devices since childhood, possessing strong abilities in online information search and digital tool use. In contrast, rural student groups are restricted by weak digital infrastructure and family economic conditions, and some students have not systematically operated office software when entering school. Differences in professional backgrounds also significantly affect the starting level of digital literacy. Students majoring in computer-related fields have a basic understanding of programming logic and system architecture, while students majoring in medical and nursing fields mainly rely on digital application experience in daily life. The unified training model makes students with solid foundations feel that the curriculum content lacks cognitive challenge [4], while students with weak foundations experience frustration due to cognitive overload from the fast teaching pace, exacerbating the polarization phenomenon. This “one-size-fits-all” teaching organization method ignores learners’ cognitive differences and development needs, making it difficult to achieve the expected training effect, as shown in Table 1.

B. LACK OF DIGITAL COMPETENCE EVALUATION SYSTEM

Vocational colleges generally lack scientific and systematic competence evaluation tools in the process of digital literacy cultivation. The existing evaluation methods mainly rely on final theoretical exams and software operation tests. The evaluation content is limited to knowledge memory and single skill assessment, making it difficult to fully reflect the true level of students’ digital literacy. Theoretical exams focus on concept

definitions and principle elaboration, and students can achieve high scores through rote memorization, but there is an obvious disconnect between this exam-oriented ability and practical application ability. Although software operation tests involve practical skills, the test scenarios are highly standardized. Students only need to complete specified tasks according to fixed steps, and it is impossible to assess their comprehensive ability to flexibly use digital tools to solve unstructured problems in complex real scenarios. The simplification of the evaluation system leads to a lack of effective diagnostic feedback mechanisms in the teaching process. Teachers cannot accurately identify students’ specific shortcomings in different dimensions such as digital cognition, operational skills, and application innovation, and thus cannot provide targeted tutoring support. Students themselves also cannot clearly recognize their own ability advantages and development space, and vague learning goals lead to insufficient initiative. The lack of evaluation tools is also reflected in the lack of process data collection methods. Key information such as students’ learning behavior trajectories, resource use preferences, and problem-solving strategies has not been effectively recorded and analyzed, making the formulation of personalized training programs lack data support.

C. OBSTACLES TO THE INTEGRATION OF INTELLIGENT TECHNOLOGY APPLICATION AND TEACHING

Technologies such as artificial intelligence and big data provide innovative means for digital literacy cultivation, but vocational colleges face multiple obstacles in the process of technology application and teaching integration. Technical obstacles are manifested in the single function and poor adaptability of intelligent teaching platforms. Most existing platforms are general-purpose learning management systems, lacking functional modules customized for the characteristics of vocational education, and cannot meet the data collection and ability analysis needs of professional training scenarios. Although some colleges have introduced intelligent question banks and adaptive learning systems, the algorithm recommendation logic is too simple[5], only adjusting the difficulty based on answer accuracy, without comprehensively considering learners’ cognitive styles, professional backgrounds, and vocational goals, leading to a mismatch between the pushed content and students’ real needs. Teacher-related obstacles are more prominent. Teach-

TABLE 1. Comparative Analysis of Differences in Vocational College Students' Digital Literacy Foundations

Dimension of Difference	Characteristics of High-Level Groups	Characteristics of Low-Level Groups	Performance of Ability Gap
Student Source Background	Urban fresh graduates with good family digital environment	Rural student sources with limited access to digital devices	A 2-3 year gap in basic operation skills
Major Type	Technology-related majors such as computer science and e-commerce	Non-technical majors such as medical care and preschool education	Significant gap in technical understanding ability
Learning Experience	Experience in programming or digital creation	Only limited to social media and entertainment applications	Obvious gap in innovative application ability
Cognitive Style	Prefer independent exploration and problem-solving	Accustomed to structured guidance and imitative learning	Differences in learning strategy adaptability

ers' understanding and application abilities of intelligent technology vary. Older teachers are accustomed to traditional teaching models and hold a wait-and-see or even resistant attitude towards digital teaching tools. Although young teachers have a higher acceptance, they lack professional training to deeply integrate technology into teaching design. To address this, a hierarchical teacher training system is established, supplemented by simplified intelligent teaching tools and collaborative support mechanisms to enhance teachers' adaptability to digital teaching. Organizational obstacles are reflected in the lack of sound technical support and incentive mechanisms in schools. Teachers need to invest additional time and energy to attempt technological innovation, but the assessment and evaluation system still focuses on traditional teaching indicators, and innovative achievements have not been fully recognized. These obstacles are intertwined, making intelligent technology remain at the display level and fail to truly empower teaching reform.

IV. DESIGN OF PERSONALIZED CULTIVATION PROGRAMS BASED ON LEARNER PROFILES

A. DEVELOPMENT AND APPLICATION OF DIGITAL COMPETENCE DIAGNOSTIC TOOLS

Constructing accurate learner profiles requires the development of multi-dimensional digital competence diagnostic tools. These tools integrate quantitative evaluation and qualitative analysis methods to comprehensively collect students' ability data and behavioral characteristics. The design of diagnostic tools includes three core modules. The basic competence evaluation module assesses basic skills such as computer operation, network application, and information retrieval through standardized question banks. The system automatically records answer accuracy, completion time, and operation paths to quantitatively evaluate skill proficiency. The professional application evaluation module designs situational tasks according to the characteristics of different majors. Students majoring in intelligent manufacturing need to complete CAD modeling and data analysis tasks, while students majoring in e-commerce need to complete marketing plan design and data visualization tasks to assess students' ability to apply digital tools to solve professional problems. The learning behavior analysis module tracks students' online learning trajectories through intelligent learning platforms, records data such as resource access frequency, learning time distribution, and interaction behavior patterns, and uses learning analysis technology to mine students' cognitive styles and learning preferences[6]. The data from the three modules converge to form a multi-dimensional profile including ability level, professional characteristics, and learning traits, providing accurate basis for subsequent hierarchical and classified training. The diagnostic tools need to establish a dynamic update mechanism to ensure that the training programs are synchronized with students' actual status, as shown in Table 2.

B. ESTABLISHMENT OF HIERARCHICAL AND CLASSIFIED TRAINING GOALS

Based on learner profile data, a hierarchical and classified training goal system is established to balance unified standards and differentiated needs. The hierarchical dimension divides students into three levels according to their digital literacy development level: basic level, advanced level, and excellence level. Students at the basic level need to meet the basic requirements of proficient use of digital tools and effective information management, and be able to independently complete routine tasks such as document editing, data sorting, and network retrieval. Students at the advanced level need to master digital technology application methods in professional fields, be able to use data analysis tools to interpret industry data, use professional software to complete design and development tasks, and use digital platforms to optimize work processes. Students at the excellence level need to have digital innovation ability, be able to design digital solutions for complex problems, and develop simple applications or digital products. The classification dimension sets differentiated goals according to professional characteristics and vocational orientations. Technology-related majors strengthen the cultivation of programming thinking and system development capabilities, service-related majors focus on improving digital marketing and customer management capabilities, and management-related majors emphasize the training of data analysis and decision support capabilities. The hierarchical and classification dimensions intersect to form a goal matrix[7], and each student matches the corresponding goal positioning according to the profile results, enabling them to grow within the zone of proximal development.

TABLE 2. Framework and Evaluation Dimensions of Digital Competence Diagnostic Tools

Diagnostic Module	Evaluation Dimensions	Evaluation Methods	Data Collection Content	Application Value
Basic Competence Evaluation	Technical operation, information management	Standardized tests	Answer accuracy, completion time, operation steps	Determine the starting ability level
Professional Application Evaluation	Situational problem-solving	Task-based assessment	Program quality, tool selection, innovation level	Identify professional application shortcomings
Learning Behavior Analysis	Cognitive style, learning preferences	Data mining	Access paths, time distribution, interaction patterns	Match personalized resources

C. DIFFERENTIATED CURRICULUM CONTENT AND TEACHING STRATEGIES

The design of differentiated curriculum content needs to construct a modular and combinable resource system to meet the learning needs of students at different levels and types. The curriculum content is divided into core modules and extended modules. Adopting a 'universal foundation + professional expansion' structure, the core modules include unified compulsory content aligned with national vocational education standards,

industry safety norms, and legal certification requirements—such as digital ethics, basic data literacy, network security norms, and general tool operation logic—to ensure all students meet quality equivalence and basic vocational employability requirements. Based on professional characteristics, ability levels, and career development needs, flexible extended modules are designed: basic-level students focus on skill reinforcement and repeated practice, advanced-level students emphasize professional scenario application and knowledge transfer, and excellence-level students focus on innovative practice and comprehensive application, avoiding homogenized training. Extended modules develop differentiated learning resources according to hierarchical and classified goals. The extended content for students at the basic level focuses on repeated practice and strengthening of operational skills, equipped with detailed step-by-step guidance and operation demonstration videos, and gradually improves proficiency through task-driven methods. The extended content for students at the advanced level focuses on professional application scenarios, providing real industry cases and project tasks, and guiding students to deepen skill application and knowledge transfer in the process of problem-solving[8,9]. The extended content for students at the excellence level emphasizes innovative practice and comprehensive application, setting open project challenges to encourage students to independently design digital solutions. The differentiation of teaching strategies is reflected in the flexible adjustment of teaching organization forms and support methods. Students at the basic level adopt a combination of small-class tutoring and peer assistance, students at the advanced level adopt a combination of project-based learning and enterprise practice, and students at the excellence level adopt a combination of tutorial system and independent research.

V. IMPLEMENTATION MECHANISM AND QUALITY ASSURANCE OF PERSONALIZED CULTIVATION

A. CONSTRUCTION OF INTELLIGENT LEARNING ENVIRONMENT

The intelligent learning environment is the technical infrastructure supporting the implementation of personalized cultivation. It is necessary to integrate intelligent learning platforms, virtual simulation systems, and data analysis tools to form a digital learning ecosystem connecting inside and outside the classroom. The intelligent learning platform should have adaptive push functions, dynamically adjust learning paths and resource presentation methods according to learner profiles and real-time learning data. It pushes moderately difficult micro-lecture videos and operation practice tasks for students at the basic level, recommends industry case libraries and project training resources for students at the advanced level, and provides cutting-edge technical literature and innovative practice platforms for students at the excellence level. The virtual simulation system constructs training environments close to real vocational scenarios[10,11]. Students can conduct equipment operation training in virtual factories, carry out marketing planning practice on simulated business platforms, and experience intelligent production processes in digital workshops, reducing training costs while improving operational safety and the feasibility of repeated practice. Data analysis tools are embedded in the entire learning process, real-time collecting students' learning behavior data, homework submission records, assessment score distribution and other information. An intelligent teaching assistance platform is developed to automatically analyze data and generate intuitive visual reports, reducing teachers' workload in data processing. Using learning analysis technology to generate visual ability development maps helps teachers accurately identify learning difficulties and provide students with personalized learning suggestions and resource recommendations, transforming teaching decisions from experience-based judgment to data-driven. For teachers with weak digital adaptability, basic training on platform operation and simplified data interpretation is provided; competent teachers participate in advanced training on learning analysis and personalized teaching design. A teacher-student collaborative support mechanism is also established, encouraging students with strong digital skills to assist teachers in data collection and preliminary analysis. Schools improve incentive mechanisms to recognize teachers' technological innovation achievements in assessments, enhancing their enthusiasm for digital teaching transformation.

B. MULTI-AGENT COLLABORATIVE EDUCATION SYSTEM

The effective implementation of personalized cultivation requires the construction of a multi-agent collaborative education network involving schools, enterprises, and families, breaking the limitations of single-agent training. At the school level, it is necessary to establish an inter-departmental collaboration mechanism. The academic affairs department is responsible for curriculum system design and teaching quality monitoring, the student affairs department focuses on students' development needs and psychological support, and the information technology department provides platform operation and maintenance and technical training, forming a collaborative work pattern. Enterprises deeply participate in the training process, co-construct digital training bases through school-enterprise cooperation[12,13], select technical backbones as part-time tutors, provide students with real project practice opportunities and career development guidance, and make digital literacy cultivation closely align with industrial needs and technological frontiers. As an important supporting force, families receive popularization of the importance of digital literacy from schools through parent-teacher meetings, online platforms and other channels. Schools guide parents to create a good digital learning environment for students, supervise students' rational use of digital devices, and pay attention to the development of their digital behavior norms. A regular communication mechanism is established between teachers, enterprise tutors, and parents to regularly exchange students' ability development status and existing problems, and collaboratively formulate targeted support plans, forming an all-round education synergy to ensure the effective implementation of personalized cultivation programs with the support of multiple agents, as shown in Table 3.

C. PROCESS EVALUATION AND DYNAMIC ADJUSTMENT MECHANISM

The establishment of a process evaluation mechanism is a key link to ensure the quality of personalized cultivation, which needs to shift from summative evaluation to full-process monitoring and dynamic feedback. The evaluation system includes three levels of indicators. The ability progression indicators track students' development trajectories in dimensions such as digital cognition, operational skills, and application innovation, collecting data through multiple methods such as phased assessments, project work evaluations, and practical performance records to depict students' ability improvement curves [14]. The learning input indicators monitor students' behavioral data such as learning time, resource use frequency, and interaction activity, identifying early warning signals of insufficient learning motivation or deviated direction. The achievement output indicators evaluate the quality of projects completed by students, the innovation of problem-solving, and the professional level of digital works, assessing the comprehensive application effect of literacy in real scenarios[15].

The data of the three types of indicators are integrated and processed through an intelligent analysis system to generate personalized development reports for students. Teachers timely adjust teaching strategies and resource allocation according to the report content, increase tutoring frequency and support intensity for students with slow progress, and provide more challenging learning tasks for outstanding students. The dynamic adjustment mechanism ensures that the training programs are optimized synchronously with students' development status. A comprehensive diagnostic evaluation is conducted at the end of each semester, incorporating prerequisite proficiency assessments. Students can only adjust their levels if they meet the basic ability thresholds of the target track (e.g., mastering basic data analysis skills before entering the 'intelligent production application' track). A supporting mechanism for dynamic adjustment is established, including a track transfer record system and peer-assisted learning groups to help transferred students make up for prerequisite knowledge within 2-3 weeks. The evaluation cycle is synchronized with key teaching stages (mid-semester and end-of-semester) to avoid disrupting normal teaching order. Meanwhile, the progressive development of digital literacy is supported by structured curriculum design: the learning content of each track follows a 'prerequisite-core-advanced' progression, and the diagnostic evaluation includes an assessment of prerequisite mastery to ensure students have the necessary foundation before advancing, thus maintaining the orderliness and operability of track adjustments.

TABLE 3. Main Responsibilities and Collaborative Mechanisms of the Multi-Agent Collaborative Education System

Collaborative Agent	Core Responsibilities	Specific Actions	Collaborative Interfaces	Expected Outcomes
School	Curriculum design and implementation	Hierarchical teaching, resource development, platform construction	Regular coordination meetings	Improved training system
Enterprise	Practice platform and tutoring	Co-construction of training bases, project guidance, technical training	Co-construction of industrial colleges	Alignment with vocational needs
Family	Environmental support and supervision	Equipment guarantee, behavior guidance, learning supervision	School-family communication platform	Formed education synergy

VI. CONCLUSION

The artificial intelligence era brings new opportunities and challenges to the cultivation of digital literacy in vocational education, requiring a shift toward mastering intelligent manufacturing systems and automated fiber performance analysis. The construction of a personalized cultivation path is a systematic project that requires the collaborative innovation of educational concepts, technical means, organizational models, and evaluation mechanisms. By accurately grasping the individual differences and common laws of vocational college students' digital literacy development, giving full play to the advantages of artificial intelligence technology in learning diagnosis, resource recommendation, and process monitoring, and establishing a hierarchical and classified training system and a multi-agent collaborative support network, the pertinence and effectiveness of digital literacy cultivation can be effectively improved. In the future, it is necessary to deepen theoretical research and practical exploration into intelligent manufacturing and performance analytics to bridge the digital divide, improve teachers' digital teaching capabilities, and promote the digital transformation of vocational education for a skilled society.

AUTHOR CONTRIBUTIONS

Xiaoyu Li designed, collected and analyzed the data, and drafted the manuscript. Xiaoyu Li conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Xiaoyu Li participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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