Artificial intelligence will empower education in 2025

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Abstract: 2025 marks a pivotal preparatory phase preceding the explosive growth of artificial intelligence(AI)technology.Its integration into education is driving systemic transformation from"standardized instruction"to"personalized enhancement".This paper examines key annual advancements in AI-powered education,focusing on three core domainsintelligent teaching agents, edge-based educational AI hardware,and AI governance frameworks.Research findings reveal a global educational AI ecosystem characterized by both competition and collaboration.The study concludes that engineering implementation and compliant applications remain current priorities.Future efforts should emphasize educational ethics and multimodal teaching integration,propelling AI evolution from educational auxiliary tools to"human-machine collaborative enhanced educational partners".

1. Introduce

1.1 Research Background.

After accumulating perceptual intelligence,artificial intelligence technology is entering a critical transition period in education from"teaching assistance"to"cognitive empowerment"by 2025.While the digital transformation of education appears stable on the surface,transformative changes are brewingbreakthroughs in autonomous decision-making capabilities of intelligent teaching agents,large-scale deployment of edge-based educational AI,and accelerated development of global AI governance frameworks for education.According to Gartner's Education Technology forecast,45% of K-12 schools and 60% of higher education institutions will fully deploy intelligent teaching agent systems by 2028.By 2025,the global edge-based educational AI market has reached $18 billion,with educational hardware terminals accounting for over 60% of the market.These figures highlight the strategic significance of AI empowerment in education this year—it represents not just technological iteration,but the starting point for reconstructing educational supply models,teaching interaction methods,and learning evaluation systems.This article systematically reviews key technological breakthroughs, innovations in teaching scenarios, and evolving governance patterns in AI-powered education by 2025, providing insights into the development logic and future trends of educational AI[1].

1.2 Research Objectives and Significance

This study aims to systematically map out key technological breakthroughs in AI-enhanced education by 2025,conduct in-depth analysis of AI applications across K12 education,higher education,and vocational training,summarize best practices from exemplary cases,and identify current challenges in implementation.By integrating global AI governance frameworks and competitive landscapes,the research proposes actionable pathways for future AI development in education,providing decision-making references and practical guidance for educational authorities,schools,and enterprises.

From a practical perspective, this study proposes education AI governance recommendations tailored to China's national conditions by analyzing the global governance framework and China's practices. It provides practical guidelines for introducing education AI technology into schools (especially primary and secondary schools and vocational colleges), clarifying the application paths and risk mitigation methods of education AI in different scenarios through summarizing typical cases.

2. Current status of core supporting technologies for educational AI

The technological advancements in AI-powered education for 2025 will see multimodal education large models break through the limitations of single-format instruction,achieving deep cross-modal integration of"text-image-voice-learning data".Intelligent teaching agents,combining large language models with educational reinforcement learning,establish a closed-loop teaching capability encompassing"learning analytics,instructional planning,interactive execution,and performance feedback",shifting from passive student response to proactive design of personalized learning paths.Furthermore,the application of neuromorphic processing units in educational terminals drives deep integration of edge computing with educational scenarios,providing hardware foundations for edge-side personalized learning[2].Meanwhile,blockchain-based traceability and AI watermarking technologies in education serve as critical trust mechanisms to safeguard teaching data privacy and intellectual property rights,supporting the implementation of AI governance frameworks in education.
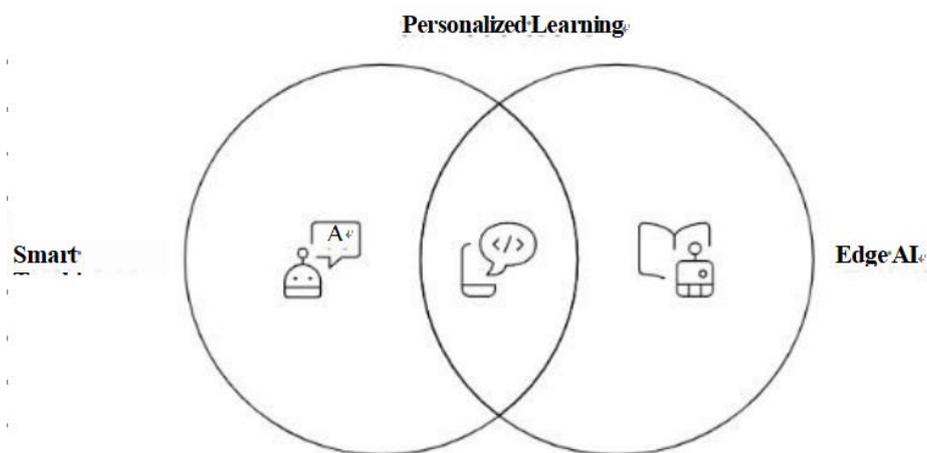

Figure 1.   Key Technology Categories

2.1 Multimodal Education Large Models and Intelligent Teaching Agent Architecture

The breakthrough of multimodal education large models in 2025 hinges on"teaching adaptability optimization"achieving a leap from"general understanding"to"teaching-specific capabilities"through the integration of educational cognitive logic modules.Tsinghua University's"EDU-PRIME"educational large model adds"learning diagnostics"and"teaching strategy generation"modules to traditional multimodal frameworks.Using only 1/8 of the training data volume of general models,it demonstrates 28% higher student comprehension accuracy in complex teaching tasks like K12 math problem-solving guidance and higher education course difficulty analysis compared to GPT-4o Education Edition.Notably excelling in"abstract concept visualization transformation,"it achieved an 81% mastery rate for quantum tunneling effects in

university physics through dynamic multimodal demonstrations,compared to 52% in conventional methods[3].

ByteDance launched the"Edu-Byte-MoE"educational sparse model,which adopts a hybrid architecture of"subject-specific expert layer + general teaching interaction layer"independent expert modules are set up for core subjects such as mathematics,Chinese,and English,while basic modules are reused in general scenarios like teaching communication and learning emotion recognition.While maintaining the teaching capability of hundreds of billions of parameters,this model reduces the inference cost of educational terminals by 65%,enabling primary and secondary school teachers to generate personalized courseware through ordinary teaching tablets.The single-generation time has been shortened from 15 minutes in 2024 to 3 minutes.Currently,it has been piloted in over 800 primary and secondary schools across 12 provinces and cities nationwide.

The intelligent teaching agent framework has evolved from a"Q&A tool"to a"personalized learning companion".Developed by Stanford University in collaboration with educational institutions,the"AutoEduAgents"framework can interpret students 'learning objectives through natural language and automatically break down learning tasks intobasic concept mastery to problem decomposition to error analysis to comprehensive testing.It coordinates multi-toolchains for executionusing learning analytics to identify weaknesses,generating targeted exercises through educational resources,and conducting real-time assessments via interactive testing.Pilot programs in 10 North American high schools demonstrated a 40% average improvement in student learning efficiency and a 55% reduction in teachers' homework grading time.Currently adopted by over 50 universities including MIT and UC,as well as K-12 school districts,the framework supports after-school tutoring and personalized learning planning.

2.2 Educational AI Hardware Support and Data Trust Mechanism

At the hardware level,neuromorphic education chips achieve dual breakthroughs of"low power consumption + high adaptability,"providing computational power guarantees for personalized learning on the edge.Huawei,in collaboration with educational equipment manufacturers,launched the"Ascend-Edu910B"chip,which adopts 3D stacking technology and dedicated computing scheduling algorithms for educational scenarios.While supporting core teaching functions such as"real-time learning analysis"and"offline personalized exercise generation,"the chip achieves three times the computational density of the previous generation with a 52% reduction in energy consumption.Student tablets equipped with this chip can perform offline AI interactive learning for up to 8 hours continuously,representing a 120% improvement in device battery life compared to 2024.It has been widely applied in remote areas for "smart education poverty alleviation"projects,addressing the shortage of personalized learning resources in regions with weak network connectivity[4].

Quantum-edge fusion technology has achieved substantial progress in optimizing educational resources.The"Quantum Education Edge Node"developed by Alibaba's Education Technology team addresses large-scale combinatorial optimization challenges in university library resource allocation and K12 school district teaching resource distribution.By employing quantum annealing algorithms,it resolves the "multi-campus resource balancing personalized demand matching "problem.For instance,when allocating high-quality teaching video resources to 20 middle schools in a provincial capital city,the system achieves 100 times faster computation speed compared to traditional GPU solutions while consuming only 1/6 of the energy.Additionally,it dynamically adjusts resource prioritization based on school-specific learning data,resulting in a 68% increase in high-quality resource utilization.

In terms of trust mechanisms,blockchain and educational AI watermarking technology form a dual defense system of"data privacy protection and copyright protection for teaching materials".The"EduTrust"system jointly launched by Ant Chain and education authorities stores students 'learning data on the blockchain through hash values,with access authorization limited to teachers and students themselves via encryption keys,achieving"data availability without visibility".During pilot implementation at 10 universities in Zhejiang Province,the system effectively reduced student data leakage risks,increasing parental trust in educational data security from 63% to 92%.

3. Key technologies and applications of AI education

By 2025, educational AI will achieve a breakthrough in application from 'single-point pilot' to 'large-scale universal access'.Significant progress will be made in four key areasintelligent teaching agents,edge-based educational AI,AI governance in education,and the global competitive landscape,driving educational AI from a technical concept to a tangible educational productivity force.

3.1Intelligent Teaching AgentsFrom Auxiliary Tools to"Digital Teacher Partners"

The core breakthrough of intelligent teaching agents in 2025 lies in achieving"closed-loop teaching capabilities"and"deep adaptation to educational scenarios,"evolving them from mere"Q&A tools"into"digital teacher partners"that participate in the entire teaching process.In K12 education scenarios,the"Jiaoxiaobao"series of multi-intelligent teaching agent systems developed by Ant Group in collaboration with educational institutions has established a complete closed loop of"learning diagnostics-instructional planning-interactive execution-effectiveness review."By integrating students 'classroom response data,homework completion status,and classroom attention monitoring data,personalized learning profiles are generated.Based on reinforcement learning algorithms,the system designs differentiated teaching paths for different students.prioritizing foundational concept breakdown videos and step-by-step exercises for math-weak students,while pushing extended thinking questions and interdisciplinary application tasks for high-achieving students.In pilot programs across 20 primary and secondary schools in Jiangsu Province,this system improved mathematics average scores by 15%,increased English listening comprehension accuracy by 22%,and reduced teachers' lesson preparation time by 40%[5].

In higher education,"specialized intelligent teaching agents"have emerged as a breakthrough solution.China's"Huajiao AI Assistant"system addresses key challenges in STEM and medical education.For mechanical engineering courses,it uses 3D modeling and AR technology to dynamically demonstrate engine disassembly processes.Students can control demonstration steps through voice commands and ask real-time questions like"force analysis of a specific component,"with the system providing visual explanations combining mechanical formulas and 3D models.In medical education,the agent integrates electronic medical records,imaging data,and textbook knowledge to assist teachers in case-based teaching.For instance,during surgical procedures,it simulates operational risks across different scenarios and provides real-time improvement suggestions when students make mistakes.Pilot programs at eight tertiary hospitals' affiliated medical schools in China have shown this system increased student pass rates in surgical proficiency assessments by 18% and boosted case analysis scores by 25%.

Current intelligent teaching agents still face two major challengesFirst,the lack of transparency in algorithmic decision-making due to the"black box"nature of algorithms—when the agent system recommends a certain type of practice questions,teachers struggle to intuitively understand"why this

type of questions was selected."Second,the difficulty in determining responsibility attribution after teaching errors.To address these issues,the"teaching operation log traceability"technology based on consortium blockchain is emerging as a core solutionBy storing decision-making bases and operational processes through blockchain,teachers and educational regulators can trace and query anytime.Currently,this technology has been piloted in 6 leading domestic education tech companies and 20 key schools,effectively enhancing the explainability and regulatory compliance of educational AI.

3.2Edge AI Education.

Through the synergy of specialized neuromorphic chips and lightweight educational models, hardware and algorithms are driving inclusive learning. This breakthrough is transforming edge AI education from pilot testing to widespread adoption,with notable success in remote education equity and personalized after-school learning.

In the field of basic education hardware,the adoption rate of AI-powered educational devices has seen explosive growth[6].By 2025,global shipments of AI-powered educational tablets are projected to reach 52 million units,marking an 85% increase from 2024.Over 70% of these devices feature dedicated educational NPU chips,enabling core functions like"offline learning analytics","real-time speech evaluation",and"personalized exercise generation".For instance,when students complete English essays offline,the tablet can instantly correct grammar errors and provide optimization suggestions using locally deployed lightweight educational models,achieving 92% accuracy comparable to human teachers.AI-powered educational PCs are also rapidly advancing.By deploying lightweight specialized educational models locally,they support university students in tasks such as"real-time code correction"and"rapid experimental data analysis".By 2025,the global adoption rate of AI-powered educational PCs in universities is expected to exceed 55%,representing a 30 percentage point increase from 2024.

In vocational education scenarios,edge AI hardware drives the"digitalization of practical teaching".The"Edu-EdgeAI-Pro"solution launched by Siemens Education,equipped with its self-developed neuromorphic education chip,can collect real-time operational data from students 'practical equipment.Through a lightweight anomaly detection model,it identifies operational risks in advance and provides real-time guidance for improvements via voice and screen prompts.In a pilot program at 15 vocational colleges in China for automotive manufacturing majors[7],this solution reduced students' operational error rate by 40%,decreased equipment damage rate by 35%,and improved the efficiency of single training sessions by 25%.

3.3Global AI Governance Framework in Education.

From 'Principal Advocacy' to 'Scenario-Specific Compliance' The core trend in global AI governance for education by 2025 is the shift from 'general AI governance principles' to 'sector-specific regulations'. Risk classification and tiered supervision have become the mainstream paradigm,with the governance framework demonstrating a three-tiered collaborative approach of 'legal enforcement + industry self-regulation + school implementation'.

The EU's"AI Act"will take effect in 2025[8],classifying educational AI systems into four risk categories:"prohibited,""high-risk,""medium-risk,"and"low-risk."It explicitly bans AI systems that"use biometric data to assess students' learning ability discrimination."High-risk categories include"AI-based college entrance exam grading,K12 core subject intelligent teaching agents,"and"university admissions AI screening systems,"which must undergo mandatory compliance assessments.Companies are required to submit 15 core documents,including"legitimacy certificates of teaching data sources,algorithm fairness test reports,"and"long-term tracking data of

teaching effectiveness."Non-compliant companies may face fines up to 6% of their global turnover,while schools violating regulations will be suspended from applying for educational funding.

China adopts an educational AI governance model of"categorized regulation + local management + school filing,"establishing differentiated rules for different educational stages and application scenariosIn the K12 stage,applications such as"AI homework grading"and"intelligent teaching recommendation"are subject to a filing system,requiring that generated teaching content be labeled as"AI-assisted generation"and must not replace teachers in delivering core knowledge points.In higher education,"research-assisted AI"and"professional course AI teaching tools"undergo categorized reviews,with medical education AI needing to pass clinical teaching effectiveness verification and engineering education AI complying with industry skill standards.Additionally,the Ministry of Education has issued the"Education AI Data Security Guidelines,"clarifying the boundaries for collecting student learning data,storage periodsand sharing rules

Corporate and institutional governance practices are accelerating implementation, transforming educational AI compliance from"policy requirements"into"operational workflows".EY,in collaboration with the Education Technology Association,has launched the"Education AI Compliance Sandbox"platform featuring three core functions

1) data bias removal tool"that identifies gender and regional biases in teaching data and automatically generates corrective solutions.

2) An"ethical impact assessment module"that provides visual analysis of AI teaching agents' decision-making logic, helping teachers understand the rationale behind recommended teaching strategies.

3) A"real-time monitoring system"that dynamically tracks AI education applications' operational metrics with automatic alerts when thresholds are exceeded. Through pilot programs involving 30 K-12 schools and 10 education tech companies in China,the platform has improved algorithmic fairness metrics by 35%,reduced compliance costs by 22%,and increased teacher trust in AI-powered education from 58% to 83%.

3.4 Global Education AI Competition Landscape.

By 2025,a competition pattern centered on China and the United States will emerge in the global education AI field,with both countries leveraging their distinct advantages to build differentiated ecosystemsthe United States dominates the high-end market through technological barriers in high-end education chips and general education large models,while China breaks through with open-source education ecosystems and localized scenario implementation,forming a complementary"technology-scenario"competitive posture.

The United States maintains a leading position in core AI technologies for education.NVIDIA's GB300-Edu chip[9],manufactured using 4nm technology,optimizes computational scheduling for educational scenarios.While supporting real-time rendering of multimodal teaching videos and parallel analysis of large-scale learning data,it reduces energy consumption by 30% compared to general-purpose chips,capturing 82% of the global high-end educational AI chip market.OpenAI's o3-Edu series excels in multimodal teaching content generation and cross-language educational interaction,though its closed API model imposes annual service fees of $150,000 for universities and educational institutions,limiting adoption by smaller institutions.Additionally,U.S.universities lead in"ethical research on educational AI,"with Stanford University's"Framework for Assessing Educational AI Fairness"serving as a reference for over 20 countries' education authorities worldwide.

China builds its competitive edge in educational AI through"open-source ecosystem and localized scenarios".The"Edu-R1"open-source educational model launched by the DeepSeek team performs nearly as well as the GPT-4o-Edu version in scenarios such as code teaching and explanations of classical Chinese poetry,with over 800,000 downloads[10],60% of which are from primary and secondary school teachers and rural educators.Teachers can further develop teaching tools adapted to local textbooks based on this model.For instance,a teacher in a remote area modified the model parameters to generate a Chinese composition guidance tool incorporating local folk culture,boosting students 'writing interest by 45%.Alibaba's"Tongyi Qianwen-Education Edition"combines domestic educational scenarios and offers over 200 industry-specific solutionsfor K12 education,the"AI Lesson Preparation Assistant"compatible with the People's Education Press edition and the Ministry-compiled edition can generate teaching materials and exercises aligned with the curriculum; for vocational education,tailored to local industries like manufacturing and services,the"AI Training Guidance System"was developed.In pilot programs at domestic manufacturing vocational colleges,this system increased the pass rate of students' skill assessments by 30%.

4. Problems and challenges facing the development of AI education

While educational AI is expected to make significant strides in technology, applications, and governance by 2025, it still faces core challengesenergy consumption in computing power, regional disparities in application development and teacher adaptation, inconsistent global regulations and high compliance costs, as well as shortages of interdisciplinary educators and technical experts. These issues continue to hinder the further advancement of educational AI.

4.1 Technical ChallengesHigh Energy Consumption.

As AI models for education expand in scale and application scenarios,the growing demand for computing power has led to increasingly prominent energy consumption issues.By 2025,global AI systems in education are projected to account for 3.5% of total educational electricity usage,representing a 1.2 percentage point increase from 2024.Notably,training these AI models consumes the highest proportion of energy.Training a single large-scale educational model with hundreds of billions of parameters alone equals the annual electricity consumption of 1,000 households.Moreover,the massive carbon emissions generated during training contradict the global"low-carbon development"objectives.

While neuromorphic chips and quantum computing are expected to achieve significant energy efficiency breakthroughs by 2025,they still fall short of meeting large-scale application demands.Although neuromorphic chips consume less power,their limited computational density makes them inadequate for complex educational tasks.Similarly,quantum computing,despite its rapid processing speed,remains prohibitively expensive,limiting its adoption to select universities and enterprises rather than widespread implementation.

4.2 Application LevelRegional Development Imbalance and Teacher Adaptation Gap.

Although AI-powered education has made progress in remote areas by 2025, the uneven regional development of educational AI remains a prominent issue, primarily manifested in three aspects:
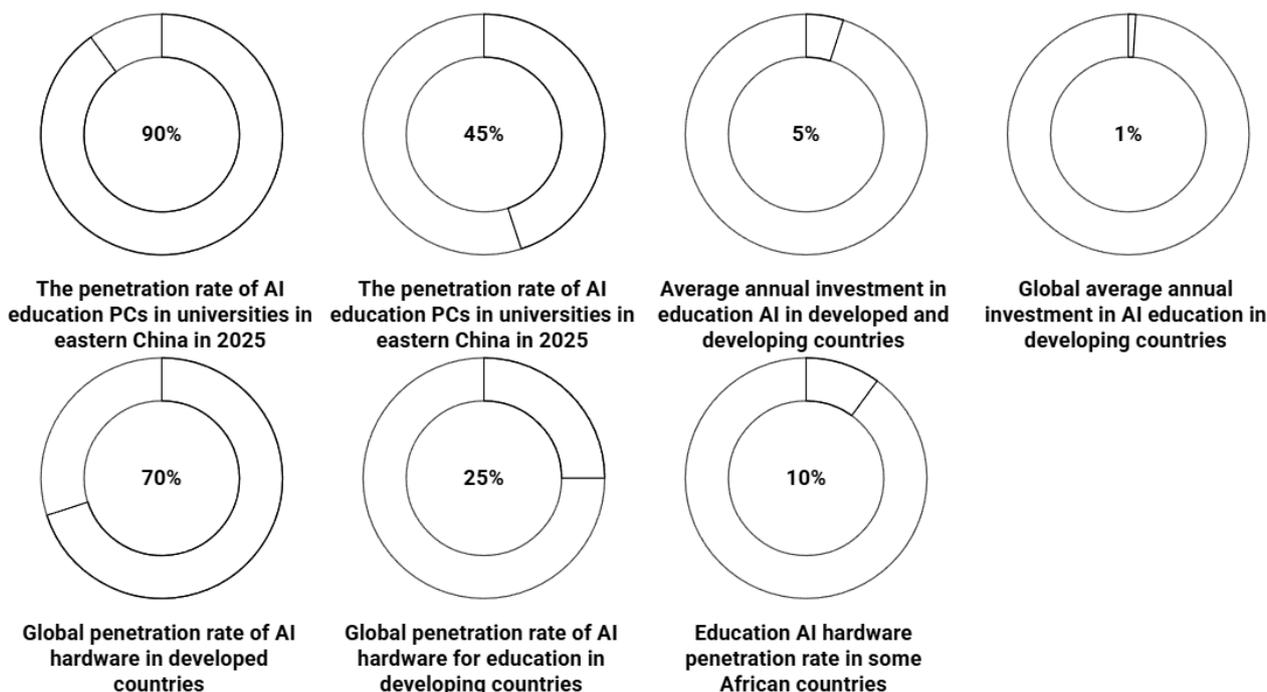
Figure 2.   Regional disparities in AI education by 2025

The uneven distribution of hardware is a key issue. By 2025,the penetration rate of AI education PCs in universities in China's eastern region will reach 90%,while in the western region,it will be only 45%.Globally,the penetration rate of AI hardware in developed countries' education reaches 70%,whereas in developing countries,it is merely 25%,and in some African countries,it is even below 10%.This hardware disparity leads to differences in access to educational resources.

Significant disparity in application depth.Schools in eastern regions not only widely adopt AI hardware for education but also extensively utilize advanced features like intelligent teaching agents and AI evaluation systems,while western schools primarily rely on basic AI educational functions,with less than 20% of institutions utilizing advanced features.Globally,developed countries demonstrate significantly deeper AI integration in education compared to developing nations.For instance,American universities routinely employ"AI-powered research support systems,"whereas only a handful of top-tier institutions in developing countries adopt such technologies.

It is the uneven investment in funds.In 2025,the average annual investment in AI education in China's eastern region reached 10 billion yuan,while the western region only reached 3 billion yuan; in developed countries,the average annual investment in AI education accounted for 5% of total education investment,while in developing countries,it was only 1%.Insufficient funding makes it difficult for developing countries and remote areas to introduce advanced AI education technologies,exacerbating the education gap.

The western region and developing countries lack interdisciplinary talents who are proficient in both education and AI,which prevents the effective application of AI in education.

5. Suggestions for the development of AI education

To address the challenges facing the development of AI in education in 2025, this paper puts forward countermeasures and suggestions from three dimensionsshort-term,medium-termand long-term,covering four areastechnology,application,governance and talent,so as to promote the healthy and sustainable development of AI in education.

5.1 Focus on Technological Breakthroughs and Application Optimization.

To address high energy consumption in computing power,short-term measures could include policy subsidies to promote the adoption of low-energy hardware in schools in remote areas.The development of"lightweight educational models"through model compression technology can reduce parameter scales from hundreds of billions to tens of billions or even hundreds of millions while maintaining teaching performance,thereby lowering computational demands.Renewable energy sources like solar and wind power should be utilized in educational AI data centers to reduce carbon emissions.For instance,establishing"Solar-powered Educational AI Computing Centers"in western remote regions could provide low-energy computing services for local schools.

5.2 Optimizing Regional Education AI Application Balance and Teacher Adaptation.

To address the issue of uneven regional development, a short-term measure could be implemented as the"Education AI Inclusive Project", increasing financial support for western regions and developing countries. For instance,China could establish a"Western Education AI Special Fund",investing 5 billion yuan annually to purchase education AI hardware and software for schools in western regions.

6. Conclusions and Outlook

6.1 Conclusion.

As a pivotal phase for AI to empower education,2025 will be characterized by technological breakthroughs, deepened application scenarios, established governance frameworks, and diversified competitive landscapes.

At the technical level,multimodal education large models have achieved a leap from general to teaching-specific applications,intelligent teaching agents have upgraded closed-loop teaching capabilities,neuromorphic chips and quantum-edge fusion technology have driven educational AI hardware toward low power consumption and high adaptability,blockchain and AI watermarking technology have established a dual defense line for data trust,and the synergy of these four core technologies has laid the foundation for the large-scale implementation of educational AI.At the application level,educational AI has made a breakthrough from single-point pilots to widespread inclusiveness,with intelligent teaching agents demonstrating significant effectiveness in K12 personalized teaching,higher education professional assistance,and vocational training guidance.

Edge-side educational AI has contributed to educational equity in remote areas through hardware popularization and quantum-edge technology applications.Global governance has formed a differentiated framework combining the EU's strict classification regulation,China's combination of classification regulation and local management,and the U.S.'s industry self-regulation.Under the dual-core competition pattern between China and the U.S.,the U.S.dominates the high-end market with advanced technology,while China achieves inclusive breakthroughs through open-source ecosystems and localized scenarios.However,educational AI still faces technical bottlenecks such as computational power consumption and"teaching hallucinations,"application challenges like regional development imbalance and insufficient teacher adaptation,governance challenges including non-uniform global rules and high compliance costs,as well as talent shortages in composite

teachers and technical professionals.These issues collectively constitute key constraints for the deep integration and development of educational AI.

6.2 Outlook.

Looking ahead, educational AI will evolve along the path of"more intelligent technology, deeper applications, more coordinated governance, and more open ecosystems."Technologically, with the convergence of brain science and AI, large-scale educational models will further achieve"educational cognitive simulation,"significantly reducing"teaching illusions"while enhancing personalized teaching precision.

Breakthroughs in green computing power and new energy storage technologies will address energy consumption challenges,driving educational AI toward low-carbon development.On the application front,educational AI will transition from being a"support tool"to becoming a"human-machine collaborative enhanced educational partner,"playing a core role in cross-disciplinary teaching,innovation cultivation,and lifelong learning services.Through the dual drivers of"digital infrastructure and educational AI,"it will continuously narrow regional education gaps,achieving the leap from"basic balance"to"high-quality balance."

In governance, global AI education regulations will seek synergy amidst differences, establishing a framework that combines"unified foundational principles with flexible regional specifics."Industry self-regulation and third-party evaluation mechanisms will be further refined to reduce compliance costs for small and medium-sized enterprises.

In talent development,teacher-training colleges and STEM institutions will deepen collaboration to build an interdisciplinary"Education+AI"training system.Simultaneously,through the"AI+Teacher Development"initiative,existing educators will transition into multifaceted roles.Over the next decade,AI in education will fundamentally reshape educational supply models and learning ecosystems,providing core support for building a high-quality education system that is accessible,personalized,and more open-flexible for all.Ultimately,this will achieve the goal of"ensuring every learner enjoys equitable and quality education."

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