

Innovative Practice of AI Empowering Preschool Education

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ABSTRACT

Artificial intelligence (AI) empowering preschool education can not only support the multiple intelligence development of young children through personalized learning, but also optimize the balanced allocation of educational resources using intelligent technology. At present, there are some problems in AI empowering preschool education, such as mismatch between technology application and children's cognition, vulnerability risk of data privacy protection mechanism, and inefficient human-machine collaboration due to weak AI ability of teachers. In this regard, it is necessary to introduce age-appropriate AI education tools to strengthen cognitive adaptability, build a full-link data security protection system, and establish a hierarchical training mechanism for teachers' AI ability, so as to achieve high-quality development of AI empowering preschool education.

KEYWORDS

artificial intelligence (AI); preschool education; educational equity; data ethics

Artificial intelligence (AI) is restructuring the ecology of preschool education with unprecedented penetration. This educational revolution started from the intervention of technology has given birth to a new practical landscape fostered by the convergence of algorithm-driven and children's cognition. The intelligent system captures the embodied learning path of children through multi-modal interaction, and its deep learning framework can not only deconstruct the cognitive logic of unstructured play behaviors, but also show technical flexibility when building a structural network for sharing urban and rural educational resources. However, when the technical logic encounters the vital rhythm of the education field, educators are faced with three dilemmas.

The mechanical decoupling of children's critical development windows by neural network architectures may induce cognitive development to deviate from the natural trajectory, the blurred boundary between dynamic data portraits and children's privacy protection is reshaping the dimension of educational ethics, and the systematic rupture between the rationality of technology tools and the practical wisdom of teachers highlights the cognitive gap of human-machine collaboration. The deep nature of these contradictions reflects the important proposition of reconstructing the educational subjectivity in the intelligent age. Starting from the theoretical framework of intelligent technology empowering education, this paper deeply deconstructs the procedural tension of technology involvement in preschool education, with a view to building an educational ethic framework with development suitability through the establishment of the "technology fit-education effectiveness" double helix model.

1 The Practical Value of AI Empowering Preschool Education

AI empowering preschool education can support the multiple intelligence development of children with personalized learning, and optimize the balanced allocation of educational resources using intelligent technology.

1.1 Support the Multiple Intelligence Development of Children through Personalized Learning

The AI system can capture the cognitive development curve, interest graph and behavioral logic of children in real time, and then generate a dynamically optimized intelligent diagnostic portrait accordingly, so that the educational intervention can shift from the universal mode to the precise drip irrigation supply. Its innovative value is to break the rigid framework of "equalization" of traditional education. Intelligent algorithms can not only analyze the developmental characteristics of multiple intelligence elements such as language logic, mathematical thinking, and spatial imagination, but also implement spiral learning schemes based on the principle of neural plasticity. This "digital mirror" technique reconstructs the practice paradigm of Gardner's theory. It not only avoids the interference of mechanized training on children's cognitive tempo, but also realizes the continuous expansion of the zone of proximal development through intelligent scaffolding. When virtual teachers can sense the three-year-old children's sensitive period of patterns and timely push the games they are interested in, and when adaptive systems can customize rhythm enlightenment programs for intelligent children in music, the technology-empowered education ecology is reshaping the implementation dimension of individualized teaching and opening up a personalized path for the cultivation of differentiated core quality.

1.2 Optimize the Balanced Allocation of Educational Resources through Intelligent Technology

Through the multi-modal technology integration and deep learning algorithm, AI can reshape the circulation system of educational resources. Relying on the full coverage of the intelligent education cloud platform, urban and rural kindergartens can synchronously access virtual simulation courses, intelligent preparation systems and personalized development assessment tools, so that the high-quality teachers and teaching methods limited by geographical separation can break through the limitations of time and space to fill in the “digital education resources depression”. The dynamic balancing mechanism empowered by technology can not only realize the real-time adaptation update of teaching resources with the help of edge computing, but also accurately match the regional education shortcomings and resource supply at the micro level through the demand prediction model driven by neural network, so as to build a closed-loop system of “demand pulling-intelligent response”^[1]. Compared with the traditional allocation model by humans, the resource flow empowered by AI presents the characteristics of self-organization and strong adaptability, which provides a more penetrating sustainable support for educational equity.

2 Current Situation of AI Empowering Preschool Education

At present, there are certain dilemmas in AI empowering preschool education, such as the mismatch between technology application and children’s cognition, the vulnerability risk of data privacy protection mechanism, and the inefficiency of human-machine collaboration due to the weak AI ability of teachers.

2.1 The Mismatch between Technology Application and Children’s Cognition

The technology of the existing AI education system is transplanted from the adult education system or the school-age curriculum framework, which forms a structural dislocation with children’s concrete thinking, situational cognition and emotional interaction needs. Developers are still stuck in the mechanical application of the theory of children’s cognitive development, and they fail to accurately grasp the embodied learning rules based on the tactile perception of children aged 2 to 6. As a result, multi-sensory collaborative stimulation is replaced by a bombardment of audio-visual content in interaction design, and programmed knowledge teaching in algorithmic logic is crowded out the exploratory play space. This cognitive bias not only causes discrete loss of children’s attention, but also builds a double barrier between technical tools and learning subjects, so that over-structured content inhibits the construction of subjective initiative. And the one-way output mode triggers the anxiety of human-computer interaction, and then develops into an emotional gap that hinders human-computer symbiosis.

2.2 The Vulnerability Risks of Data Privacy Protection Mechanism

The biological characteristics (such as pupil and voice print), behavior patterns and emotional data of children generated during interaction are highly sensitive. However, the current privacy protection framework does not establish a hierarchical protection system based on children’s cognitive characteristics. Most of the technology suppliers adopt simple data obfuscation means to only encrypt the static storage link, and fail to build a dynamic tracking mechanism of the whole process from the source of collection to the destruction of data. Taking pupil recognition as an example, the original data may still be maliciously cracked or restored during transmission, and the aggregation of deep data such as voice emotion analysis is also prone to form “data vulnerabilities”^[2]. More insidious is that AI’s continuous tracking of children’s behavioral traces may solidify and produce irreversible “digital personality portraits”. This invisible data shackle constructed by algorithms deprive children of multiple possibilities for future identity exploration, and its potential ethical crisis will break the traditional boundary of the right of privacy and evolve into a major challenge for the free development of personality.

2.3 Inefficient Human-machine Collaboration due to the Weak AI Ability of Teachers

At present, kindergarten teachers generally face cognitive fault in AI education practice. They have not established a systematic operating framework for human-machine collaboration, and found it difficult to dialectically understand the fundamental operating rules and ethical boundaries of intelligent technology. Some teachers regard the standardized evaluation report generated by AI as the standard, and mechanically implement the course scheme recommended by the algorithm, resulting in children’s personalized development needs being obscured by data indicators. Another teachers completely deny the early warning function of the intelligent system because of technology anxiety, and even oppose the Montessori teaching aids and AI diagnostic tools. This either-or cognitive bias makes intelligent technology neither truly integrate into the education closed loop of “observation-support-reflection”, nor effectively activate the ecological value

of technology empowering education, thus forming the practical paradox: “the more AI is involved, the more teaching is divided”.

3 Innovative Practice Strategies for AI empowering Preschool Education

In view of the above dilemma, it is necessary to introduce age-appropriate AI education tools to strengthen cognitive adaptability, build a full-link data security protection system, and establish a hierarchical training mechanism for teachers' AI ability, so as to achieve high-quality development of AI empowering preschool education.

3.1 Introduce Age-appropriate AI Education Tools to Enhance Cognitive Adaptability

Based on the law of children's cognitive development and the basis of brain science, AI education tools need to focus on the two-way adaptation of “age characteristics-technical response” to be applied. In tool design, embodied learning can be realized through tactile interaction and dynamic feedback. For example, it can transform abstract numbers into smart toys that integrate tactile experiences to help young children establish quantity perception through the difference in vibration frequency. And it can develop a voice interaction system with emotion recognition ability, which can automatically switches to the high-frequency interaction mode of short sentences when children are distracted, and extends the dialogue logic to cultivate the thinking coherence when children's spirits are high. The intelligent closed-loop of “perception-feedback-optimization” should be constructed synchronously, and the micro-expressions and body movements of children when operating teaching aids should be captured by biosensor technology, so as to generate the stepped learning tasks in real time^[3]. At the same time, a joint research and development team of developmental psychologist, educational engineers and front-line teachers will be set up to transform the cognitive development theory into operable technical parameters, so that AI tools can not only stimulate children's exploration interest through interactive forms, but also accurately match the brain development level of children with different age at the level of cognitive load. Thus, the technology empowerment can follow the law of children's growth.

3.2 Build a Full-link Data Security Protection System

In the preschool education scenario empowered by AI, to protect the data security, it is necessary to break through a single technical barrier and achieve systematic protection through the two-way coupling of technology ethics and institutional design. In terms of technical architecture, the hierarchical defense strategy of “end-chain-cloud” should be adopted. On the front end, the lightweight privacy computing module should be embedded to implement real-time desensitization of biometric data. On the middle end, the anti-quantum encryption algorithm and smart contract technology can be used to build a transparent tracking link of data flow. On the back end, the educational data sandbox should be developed based on zero-knowledge proof to realize physical isolation between model training and data calling. At the level of system design, it is necessary to synchronously innovate the traditional governance paradigm and establish a “dynamic hierarchical authorization” mechanism, which takes guardian decision-making as the main axis, integrates with a progressive informed module according to children's cognitive development stages, and transforms the abstract data authority into a concrete scene map based on a visual interactive interface. In order to break through the hysteresis of post-supervision, the concept of “privacy native design” can be introduced, and privacy enhancement technologies such as federal learning and secure multi-party computing can be deeply integrated into the whole process of AI product development, so as to form an dialectical unity of data availability and security, and build a child digital right protection network with “transparent algorithm traceability, dynamic authority adaptation, and active risk circuit breaker”^[4].

3.3 Establish a Hierarchical Training Mechanism for Teachers' AI Ability

When constructing the hierarchical training mechanism for teachers' AI ability, it can learn from the professional development track to build a three-dimensional advanced path of “cognitive breakthrough - practice cultivation - reflection and transcendence”. In the basic stage, virtual simulation tools are used to realize embodied learning, which allows teachers to visually observe the decision-making path and data response mechanism of AI system, and break the cognitive barriers of teachers to algorithm operation. In the practice stage, “scenario-type task chain” is adopted to strengthen the human-machine coordination ability, such as transforming the AI-generated child behavior map into a teaching scheme through games, or dynamically adjusting the teaching rhythm according to the attention fluctuation curve captured by the intelligent system. In the advanced stage, it focuses on the reconstruction of educational subjectivity, and guides teachers to identify the functional boundaries of AI in the dimensions of emotional connection

and imagination stimulation by building ethical thinking workshops and to form a dialectical thinking of “human using skills”^[5]. At the same time, the dual-track supportive system of “cloud platform + community of practice” can be built, which can provide dynamically updated smart education sandbox cases online, and organize cross-kindergarten AI teaching aids co-creation camp offline. In addition, it is necessary to incorporate technology ethic decision-making ability into teacher evaluation indicators, build a ability evaluation system covering tool application, innovation transfer, and value judgment, and promote teachers to transform from technology operators to educational innovators with digital intelligence.

4 Conclusion

The deep integration of AI and preschool education is actually the creative coupling of scientific rationality and educational wisdom in the field of education. This innovative practice requires technology developers to take the child cognitive map as the starting point of design, so that the intelligent system can not only dynamically adapt to the phased development characteristics of children, but also stimulate its exploration potential through multi-modal interaction. Education practitioners need to build an elastic boundary between intelligent assistance and humanistic infiltration, make good use of data analysis to optimize teaching decisions, and adhere to the emotional temperature and educational sensitivity of teacher-child interaction. The current technological iteration is promoting the transition of education scene from “digital twin” to “intelligent symbiosis”, which not only requires the establishment of a three-dimensional protection mechanism covering technology ethics, data sovereignty and cognitive security, but also deeply calls for the educational circles to focus on the nature of childhood in the era of intelligence: in the growth environment of virtual and reality interwoven, how to protect children’s subjective development through embodied learning design should be explored. The innovation exploration in the future should be committed to the development of AI systems with educational explanatory ability, so that the AI system can truly become the existence of expanding rather than replacing human education wisdom.

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