

Exploring the Practice of Generative AI Empowering Early Childhood Education: A Case Study of Weiyuan County Third Kindergarten

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Abstract: Generative AI provides crucial technical support for cracking the realistic dilemmas such as the lack of professional resources, unbalanced distribution of high-quality resources, and difficulties in implementing personalized teaching in the field of early childhood education. This study takes the No.3 Kindergarten of Wuyuan County, Gansu Province as case, and uses multi-dimensional data analysis to explore the application path, practical effects and optimization strategies of generative AI in early childhood education. The study constructs a four-dimensional strategy system of "quality improvement – deep integration – ethical norms – personalized empowerment": digital literacy of teachers is improved through "technical workshop" and mixed training; a linkage mechanism teaching and technology is established based on "intelligent teaching salon"; the "Ethical Norms for AI Education Application" is formulated and a diversified supervision mechanism is constructed; personalized learning support is realized based on the digital portrait of children's development. The practical effect evaluation shows that children in the experimental class have achieved a significant improvement of 2440% on the dimensions of language expression, logical thinking, problem solving, and social interaction, 82% of parents feedback that children's interest and initiative in learning been enhanced, 92% of parents are satisfied with the AI education practice, and the professional competence of teachers has also been comprehensively improved in terms of teaching design, integration, and teaching reflection. This study verifies the effectiveness and feasibility of generative AI empowering early childhood education in underdeveloped areas, and provides replicable practice paradigm for related.

Keywords: Generative; artificial intelligence; AI; infant; education

0. Introduction

The explosive development of AI technology has pushed it from theoretical exploration to large-scale practice in the field of education, the core driving force of educational modernization. As an important branch, generative AI, relying on advanced algorithms such as generative adversarial networks (GANs) and variational autoencoders (VAEs), has strong multi-modal content generation and dynamic interaction capabilities, and can provide key technical support for the innovation of educational scenarios^[1]. Preschool education, as the stone of the national education system, undertakes the mission of all-round development of children aged 3 to 6, but it still faces realistic difficulties such as lack of professional, uneven distribution of high-quality resources, and difficult implementation of personalized teaching. The "Guidelines for Learning and Development of Children Aged 3-6" put forward the of "taking play as the basic activity", and the technical characteristics of generative AI, which constructs dynamic interactive gamified scenarios and generates customized content, are highly consistent with it, can not only provide children with immersive learning experience, but also provide teachers with intelligent lesson preparation and learning analysis support. Generative AI is based on deep learning algorithms, and the algorithms include GAN, VAE, Transformer models, etc., which show three characteristics of multi-modal content generation, dynamic interaction and personalized adaptation in preschool education scenarios, and can diverse teaching resources such as stories, picture books and animations, and achieve real-time interaction and customized learning support^[2]. Its application in the field of education presents the characteristics of intelligence, ization and interaction, and fits the cognitive development law of young children, and can concretize abstract knowledge through game and

situational design, and it also has the ability to integrate share resources, and provides technical support for promoting educational equity, which constitutes the theoretical basis of technology empowerment of preschool education. Against this background, the public demonstration kindergarten in the under area of Wuyuan County, the Third Kindergarten, started the innovative experiment of "AI Preschool Education" in 2022, and the rich practical experience provides a typical case support for relevant research, and exploring its application path has become an important topic to solve the dilemma of traditional preschool education and promote the high-quality development of preschool^[3]. This study takes the Third Kindergarten of Wuyuan County as a case, and collects the practice data of the garden comprehensively through field observation, in-depth interviews, text analysis; it uses multi-modal data analysis to integrate multi-dimensional data such as texts, behaviors, and evaluations to carry out quantitative and qualitative combined analysis; it uses research to verify the effectiveness of the technology through the comparison between the experimental class and the control group and the reference of domestic and foreign results^[4].

1. Generative AI for Multimodal Learning Support

The theory of multi-modal learning is highly relevant in the field of early childhood education, as the cognitive development of children aged 3-6 heavily relies on concrete sensory experiences. Single-modal information input struggles to meet their learning needs, whereas multi-modal learning, by integrating visual resources such as images and videos auditory materials like speech and music, tangible experiences like physical manipulation, and kinesthetic activities like body movements and game interactions, can provide rich and diverse sensory stimuli for children. not only helps them construct multi-dimensional knowledge representations but also optimizes learning outcomes. Generative AI provides crucial technical support for the in-depth implementation of multi-modal learning on the one hand, automatically generating multi-type multi-modal teaching resources such as text stories, voice readings, animation videos, and interactive games based on learning goals and children's cognitive characteristics; on the other hand, it can achieve real-time interaction of multi-modal information through intelligent devices such as AR glasses and haptic feedback toys, creating immersive learning for children^[5]. The Third Kindergarten of Wuyuan County has built a "Technology-Enhanced Multi-Modal Learning Space" based on this theoretical technical integration logic, deeply embedding the concept of multi-modal learning and generative AI technology into teaching practice^[6]. For example, in math cognition activities, the multi-modal collaborative design tangible operation (haptic), graphic cards (visual), counting songs (auditory), and hopscotch games (kinesthetic) effectively enhances children's understanding and mastery of numerical concepts, providing a concrete theoretical and practical paradigm for generative AI to empower early childhood education^[7].

2. The Current Situation and Practical Challenges of Generative AI in Early Childhood Education

Generative AI has formed a multi-scene deep application pattern in the field of early childhood education, with results in three dimensions: science education, social development, and professional development of teachers. In terms of science education, the "Science Little Genius" interactive platform of the third in Wuyuan County can generate a variety of inquiry projects, such as simulating physical phenomena and observing biological growth. In the "Miraculous Change of Matter" theme activity, system can adjust the complexity of the experiment in real time according to the data of children's operation. Younger children focus on observing phenomena, older children increase variable exploration, and virtual experimental scene supports repeated attempts, which improves the integrity of children's observation records by 32% and the coherence of logical reasoning by 27%. In the of social development, generative AI constructs virtual social partners and collaboration scenarios, breaking the limits of time and space. The "AI Social Partner" system of the third kindergarten in Wuyuan County can generate virtual roles with different personalities according to children's language expression and behavior characteristics.

In themes such as "Forest Concert", it guides role-playing and task, and provides animated demonstrations and voice prompts for communication conflicts, helping children master skills such as negotiation and sharing. Children who use this system show significant improvement in the frequency of sharing and the diversity of conflict resolution strategies compared to the control group. On the level of professional development of teachers, the "AI Education Think Tank" of the third kindergarten in Weiyuan County integrates high-quality resources to form a dynamic knowledge graph. Teachers can obtain a multi-dimensional teaching plan including goals, processes, and teaching aid recommendations by entering the teaching theme the age of children. Moreover, it can optimize the plan based on teaching reflection and feedback from children. The "Teaching Situation Simulation" function in teaching research can generate predictions of children's reactions and coping suggestions. Teachers who participate in intelligent research and training show significant improvement in the innovation of teaching design and the effectiveness of children's behavior observation compared traditional training models by 31.4%. However, the application of technology still faces multiple realistic challenges: excessive expansion of instrumental rationality leads to the alienation of the of education, some kindergartens and teachers regard technology as the only means to improve quality, over-reliance on AI to generate resources and lesson plans leads to design hom, and technology application is superficial; the digital literacy of teachers is uneven, and teachers in underdeveloped areas generally have problems such as cognitive bias of technology, insufficient operational skills, and of innovative integration ability, which restrict the depth of technology application; the risk of technology substitution is showing, over-reliance on AI may weaken the core role of teachers in attention, emotional support, and value guidance, shaking the professional identity recognition of teachers; ethical and safety issues are prominent, children's personal information and data are highly sensitive, some tools lack data security protection, algorithm transparency, and content review, and China has not yet established a sound ethical norm and regulatory system in this regard, and the application of technology is. These problems need to be solved through systematic measures, so as to promote the healthy integration of generative AI and early childhood education.

3. optimization strategies for generative AI to empower early childhood education

In view of the realistic challenges of generative AI applications in early childhood education, it is necessary to construct a fourdimensional optimization strategy system of "literacy enhancement-deep integration-ethical norms-personal empowerment" to promote the benign interaction of technology and educational ecology. In terms of improving teachers' literacy, the Third Kindergarten of Weiyuan County adopts the "Technology Workshop" model to carry out thematic training such as "Picture Book Generation and Application" and "Student Situation Analysis and Intervention", and to enhance practical ability through role-playing and case simulation; at the same time, it innovates the way of blended training online offline, provides flexible learning resources based on MOOC platform, and forms a closed-loop support mechanism through "Technology Mentoring System", and also includes AI application capability in professional development assessment, and stimulates learning initiative through "AI Teaching Innovation Case Selection". In terms of deep integration of technology and education, Weiyuan County Third Kindergarten organ teachers to discuss questioning plans and AI application strategies through "Intelligent Teaching Salon" and "Question Business Training Camp", designs heuristic question chains relying on AI interactive stories in language, and optimizes question difficulty around themes such as "Melting of Ice" in scientific inquiry^{[31][9]}; at the same time, it establishes a "question design-ical matching-scene application-effect feedback" linkage mechanism, constructs a multi-dimensional "question business" evaluation system, and ensures the deep integration of questioning, technology and. In terms of ethical norm construction, Weiyuan County Third Kindergarten has formulated the "AI Education Application Ethics Code", which clarifies the scope of use of AI tools data collection standards and content review mechanisms^[7]; at the same time, it establishes a multi-dimensional supervision mechanism of "government supervision-kindergarten self-discipline-parent supervision-technology party responsibility", establishes an

AI application ethics committee composed of representatives from various parties, establishes an application log system, regularly carries out safety assessment and ethical review, ensures the safe and compliant use of technology. In terms of personalized development support, the digital portrait system for children's development in Weiyuan County Third Kindergarten can identify development of multiple intelligences through data such as painting, language and games; based on this, generative AI sets personalized learning goals and plans according to the cognitive level and interest preferences of children, pushes compatible resources and dynamically adjusts, such as providing ladder-type voice interaction training for young children with weak language abilities, and designing extensive scientific inquiry tasks for young children strong logical thinking, and teachers track progress in real time through the system and implement targeted interventions. The four strategies work together to solve application problems from four dimensions: subject capability, mechanism, system guarantee and individual demand, and provide systematic and feasible practice paths for generative AI to empower early childhood education

4. Practice analysis

Weiyuan County No.3 Kindergarten was established in 2015 and is a public demonstration kindergarten the direct administration of the Education Bureau of Weiyuan County, Gansu Province. Located in the core educational park of the county town, it covers an area of 8600 square meters. There are currently 12 teaching classes, more than 420 children enrolled, and 58 teaching staff, including 35% teachers and 82% teachers with bachelor's degrees or higher. The kindergarten adheres to the educational philosophy of "prioritizing children's development and empowering innovation practice, and has established a trinity educational ecosystem of "playful learning, contextualized exploration, and personalized growth". In terms of hardware, it is equipped with intelligent interactive science halls, non-legacy cultural experience workshops, and other distinctive spaces, as well as AI teaching tools such as AR projection sand tables and virtual experimental equipment. In terms of curriculum it has developed a school-based "Root Buds Curriculum" system. In terms of teaching staff, it implements a "Double-teacher Growth Plan" and has set up Smart Education Research Team. It has won provincial-level awards for informatization cases in early childhood education and launched an "AI Infant Education" innovative experimental project in 022. It focuses on curriculum design, teaching interaction, and home-school cooperation to explore deep integration paths and has formed a characteristic technical application paradigm.

In application practice the kindergarten develops enhanced multi-modal courses based on generative AI development technology. Teachers can obtain a multi-dimensional plan including content, process, and teaching aid recommendations by inputting course theme, child's age, and other information into the AI education think tank system. After personalized adjustment, it is implemented on the ground. For example, the "W Plants" theme course integrates plant growth animation, voice stories, virtual planting experiments, and real-object observation tasks, effectively improving children's observation, exploration, and logical thinking. It constructs diversified intelligent interaction scenarios such as smart experiment workshops, AI social partners, and interactive picture book reading. In the "Space Exploration" themed activity, children wear glasses to enter the virtual scene, and interact with AI virtual tour guides and peers to complete knowledge Q&A, planet exploration, and other tasks. The AI system provides real-time feedback to help improve knowledge mastery and cooperation, and problem-solving abilities. It builds an intelligent home-school co-education platform with functions such as generating reports on childrens development and pushing personalized parenting suggestions. It can recommend adapted parent-child reading resources and interactive games based on the portrait of children's language development. Through the video call function it promotes efficient communication between teachers and parents to form an educational force. The application effect evaluation shows that the children in the experimental class have made significant progress in cognitive, social, and learning interest, with an increase 28% in the fluency and richness of

language expression, 32% in logical thinking ability, 24% in problem-solving ability, 3% in the frequency of cooperative behavior, 30% in the diversity of social skills, 27% in the accuracy and rationality of emotional expression, 37 in the participation in learning activities, and 40% in the increase of active exploration behavior. 82% of parents reflect that their children's learning interest and initiative significantly increased; the professional competence of teachers has been comprehensively improved, with an increase of 31.4% in the innovation of teaching design, 38% in pertinence and adaptability of teaching plans, 45% in the ability of AI tool operation and technology integration, 36% in the depth of teaching reflection and research ability, and a number of innovative cases and research results have been formed; parents have a high satisfaction rate, with 92% expressing satisfaction with AI education practice, 8% recognizing the value of the home-school cooperation platform in supporting childcare, and 85% trusting the ethical and data security protection measures of AI applications. This case provides a replicable practice paradigm for the application of generative AI in early childhood education in underdeveloped areas, fully verifying the effectiveness and feasibility of technology empowerment.

5. Summary and Prospect

This study systematically explores the application path, effect and optimization strategy of generative AI in early childhood education with Weiyuan County No.3ergarten as a case study. The core conclusion is that this technology can effectively break through the traditional early childhood education by generating personalized resources, constructing interactive scenarios and providing intelligent support. The of this technology fits the related theories such as Piaget's cognitive development theory and conforms to the characteristics of children's learning. It has solid theoretical support. Emp data verify that it can significantly improve children's cognitive and social abilities, promote teachers' professional development and improve parents' satisfaction. At the same time, it faces challenges such as expansion of instrumental rationality and the lack of digital literacy of teachers, which need to be addressed through systematic training and "question business" training. Future research can further carry out-term tracking to verify the long-term impact of technology, expand the scope of research to explore universality and regional adaptability, deepen the integration of technology and local culture and strengthen interdisciplinary cooperation to improve the theoretical and methodological system. Only by adhering to "taking children's development as the foundation", integrating educational laws and ethical, can we fully play the value of technology empowerment and build a new ecology of high-quality early childhood education.

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