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Innovation in AI-Empowered Support Models for Preschool Children's Emotional Development

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Abstract: Emotional development in preschool children is a core aspect of psychological development; however, their emotional expressions are characterized by intuitiveness, instantaneity, and instability, posing challenges for traditional support models that struggle with balancing comprehensive and non-intrusive data collection and suffer from homogenized intervention strategies. This paper focuses on the innovation of AI-empowered support models for preschool children's emotional development, analyzing their technological logic and feasibility. By leveraging technologies such as the Internet of Things, computer vision, and speech recognition, it achieves precise and unobtrusive collection and systematic processing of multidimensional emotional data. Relying on machine learning and affective computing, personalized emotional recognition models tailored to different age groups and scenarios are constructed, leading to the generation of differentiated intervention strategies suitable for both kindergarten and home settings. On this basis, an overall framework of technology-supported, dual-field collaborative, and closed-loop operation is established, innovatively proposing three sub-models: precise intervention in kindergartens, intelligent co-education in families, and seamless data integration between home and kindergarten. To ensure the implementation of these models, an AI-assisted, human-led human-machine collaboration mechanism, a dynamic assessment and feedback mechanism, as well as an ethical framework and privacy security system encompassing principles of informed consent, minimal necessity, and non-maleficence are established.

Keywords: Preschool children; Emotional development; Artificial intelligence; Support model innovation

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1. Introduction

With the in-depth integration of artificial intelligence (AI) technology and the education sector, as well as the iterative upgrades of technologies such as affective computing, machine learning, and the Internet of Things, new avenues have emerged to address the challenges of traditional emotional support. Leveraging its core strengths of multi-modal perception, intelligent analysis, and personalized adaptation, AI has broken free from the reliance on human experience inherent in traditional models. It has facilitated a transformation in emotional data collection from subjective recording to objective acquisition, emotional interpretation from empirical judgment to algorithmic modeling, and emotional intervention from uniformity to personalization,

injecting technological momentum into emotional development support for preschool children. Based on this, this paper systematically analyzes the technological logic and feasibility of AI-empowered emotional development, grounded in the developmental patterns of preschool children's emotions and the characteristics of AI technology. It constructs an innovative support model featuring technological underpinning, dual-field collaboration, and closed-loop operation, clarifies the collaborative pathways and operational mechanisms within the two major settings of kindergartens and families, and establishes a corresponding ethical and safety assurance system.

2. Technological logic and feasibility of AI-empowered emotional development

2.1. Collection and processing of children's emotional data

Emotions trigger the occurrence of psychological activities and constitute a crucial aspect of psychological development. Childhood serves as the foundation for all psychological development, with the emotional development of preschool children being particularly significant during this period. Preschool children are at a rapidly developing stage, characterized by highly malleable psychological functions and extreme sensitivity to external environmental stimuli. They are prone to forming neural connections, accumulating individual life memories, and establishing trajectories of emotional development. Additionally, children possess unique ways of interacting with the external environment that influence their emotional development [1]. The emotional expression of preschool children is characterized by intuitiveness, instantaneity, and instability. Traditional data collection methods struggle to balance comprehensiveness and non-intrusiveness, whereas artificial intelligence technology achieves precise and unobtrusive collection of emotional data through multi-modal sensing approaches [2]. In terms of data collection dimensions, relying on Internet of Things (IoT) devices and computer vision technology, it captures children's facial expressions (such as smiling, frowning, crying, etc.) and physical movements (such as curling up, running, frequency of physical contact, etc.). Through speech recognition technology, it extracts features such as tone, speech speed, and semantics to determine emotional undertones (such as happiness, anger, anxiety, etc.). By integrating intelligent picture books, interactive toys, and other carriers, it collects data on children's operational behaviors (such as duration of stay, preference in choices, etc.), thereby constructing a multi-dimensional emotional data matrix [3]. In the data processing phase, interference information (such as environmental noise, incidental movements) is removed through data cleaning. Feature extraction algorithms are employed to select core indicators strongly correlated with emotions. Subsequently, through data standardization, unstructured data (expressions, speech) is transformed into structured data, providing high-quality data support for subsequent emotional understanding and modeling.

2.2. Emotional understanding and modeling

Emotional understanding and modeling represent the core components of AI-empowered emotional support, focusing on constructing emotion recognition models tailored to preschool children to overcome the limitations of adult emotion models [4]. Based on the collected multidimensional data, leveraging machine learning (such as deep learning and support vector machines) and affective computing technologies, we construct a child emotion recognition model tailored to different age groups and scenarios. Given the straightforward and singular nature of emotional expression in 3- to 4-year-olds, the model prioritizes the recognition of basic emotions (joy, anger, sadness, fear). For 5- to 6-year-olds, whose emotional expressions become more complex, the model enhances its ability to identify compound emotions (such as feeling wronged, jealousy, pride) [5]. To improve the model's accuracy, it is trained using preschool children's emotional development theories and extensive real-world

scenario data, correcting biases inherent in adult emotion recognition algorithms (for instance, a child's crying may correspond to multiple emotions like anger, fear, or feeling wronged, requiring a comprehensive assessment based on body language and vocal characteristics) [6]. Additionally, through a dynamic iterative mechanism, the model continuously incorporates emotional data from diverse children to optimize its parameters, enabling an upgrade from universal to personalized emotion recognition, precisely capturing each child's emotional expression habits and underlying issues.

2.3. Generation of personalized intervention strategies

Artificial intelligence constructs a personalized intervention strategy generation system based on emotion recognition results and individual child characteristics, addressing the limitations of one-size-fits-all traditional interventions [7]. The generation of intervention strategies must balance scientific rigor with adaptability, ensuring alignment with children's age-specific traits and emotional development patterns by integrating theories from developmental psychology and preschool education. Furthermore, it incorporates individual child information (such as personality traits, family environment, and past emotional expressions) to tailor strategies to each child's unique needs. For children with weaker emotional regulation abilities, gamified intervention programs (such as emotional role-playing games and guided picture book reading) should be developed. For emotional issues arising from social conflicts, situational simulation training and communication skills guidance should be provided. For negative emotions such as anxiety and low self-esteem, intervention activities such as mindful breathing and positive psychological suggestions should be designed [8]. Meanwhile, intervention strategies should be tailored to different scenarios, offering differentiated plans for kindergarten education and family education. The kindergarten setting should focus on emotional guidance during group activities, while the family setting should emphasize emotional comfort during parent-child interactions, ensuring the pertinence and operability of the interventions.

3. Innovative construction of support models empowered by artificial intelligence

3.1. Overall framework for model construction

Construct an overall framework featuring technological support, dual-scenario collaboration, and closed-loop operation, with artificial intelligence technology as the core support, integrating the two scenarios of kindergarten education and family education to form a closed-loop support system encompassing data collection, emotional assessment, intervention implementation, and evaluation feedback [9]. The core of the framework lies in breaking down barriers between scenarios and data, achieving a virtuous cycle of technology empowering education, education linking with families, and families feeding back data. AI technology provides precise tools and personalized solutions for both scenarios, with kindergartens and families serving as the main entities for implementing interventions, driving strategy implementation, and providing feedback on effectiveness. The new data generated feeds back into model optimization, continuously improving the quality of support. The framework takes into account technological empowerment, educational principles, and family needs, avoiding the alienation of technology replacing human companionship while breaking through the limitations of traditional models through technology, achieving precision, collaboration, and sustainability in emotional support.

3.2. Precision intervention model in kindergarten education

As the primary setting for emotional education for preschool children, kindergartens leverage AI technology

to establish a precision intervention model encompassing real-time monitoring, precise guidance, and collective co-education [10]. In daily teaching, intelligent observation devices (such as non-contact cameras and smart interactive terminals) are deployed to monitor children's emotional states in real-time during group activities, games, meals, and other scenarios. When negative emotions or emotional conflicts are detected, warning messages are promptly sent to teachers to assist them in intervening quickly. For individual children, AI provides teachers with personalized intervention recommendations. For example, for children prone to impulsivity, it suggests teachers use the calm corner guidance method, combined with emotional picture books to help them understand their emotions; for introverted and silent children, it recommends teachers design group cooperation tasks to encourage them to express their emotions. For collective emotional issues, AI generates themed educational activity plans (such as "Emotional Little Steward" themed class meetings and emotional graffiti activities) to guide all children in recognizing and learning to regulate their emotions. Meanwhile, the AI system records children's emotional development trajectories and provides teachers with periodic assessment reports to assist them in adjusting educational strategies, achieving an organic integration of individual intervention and collective education.

3.3. Intelligent co-education model in family education

Family education is a crucial setting for emotional support, and an intelligent co-education model based on AI technology is established, encompassing intelligent guidance, parent-child interaction, and effect feedback, to enhance parents' ability to guide their children's emotions and achieve scientific family emotional support. By developing an intelligent app for parents, we provide them with three core services. Firstly, we offer popularization of emotional knowledge by delivering articles and short videos on emotional education tailored for preschool children, helping parents master skills in emotion recognition and soothing. Secondly, we provide personalized guidance plans. Based on children's emotional data synchronized from kindergartens, we generate family intervention suggestions for parents (such as parent-child games and topics for bedtime conversations), guiding them to intervene in children's emotions during daily interactions. Thirdly, we incorporate an interactive feedback function, enabling parents to record children's emotional expressions and intervention effects at home and upload them to the system to form a closed data loop. Meanwhile, we enrich family intervention forms by integrating intelligent hardware (such as intelligent picture books and emotional dolls), guiding children to express their emotions through interactive mediums, and helping parents observe their children's states more intuitively. This model not only alleviates parents' anxiety about emotional education but also makes family interventions more targeted, preventing improper interventions due to parents' lack of professional knowledge and achieving a transformation from experience-based to science-based family education.

3.4. Data integration model for home-kindergarten co-education

Breaking down data barriers between home and kindergarten is crucial for achieving collaborative interventions. We have constructed a data integration model that includes secure data sharing, coordinated strategy implementation, and joint effect evaluation. In terms of data sharing, we have established an encrypted data-sharing platform where kindergartens and families upload children's emotional data and intervention records. The data undergoes anonymization and hierarchical authorization management to ensure privacy and security. The shared data covers children's performance in collective kindergarten settings, individual family settings, intervention implementation processes, and effects, providing both parties with a comprehensive emotional profile of the children. In terms of strategic collaboration, AI generates unified emotional development goals

and differentiated intervention responsibilities based on shared data. Kindergartens focus on rule guidance and social-emotional cultivation in collective settings, while families emphasize emotional companionship and behavior habit formation in individual settings, ensuring consistent intervention directions and complementary strategies between the two parties. In terms of outcome evaluation, both kindergartens and families participate in evaluating children's emotional development. AI generates periodic evaluation reports by integrating feedback from both sides and changes in data, clarifying intervention effectiveness and directions for improvement. This promotes a shift from passive cooperation to active collaboration between kindergartens and families, forming a joint force for emotional support.

4. Operational mechanism and guarantee system for model implementation

4.1. Human-machine collaboration mechanism

Clarify the roles of AI technology and educational stakeholders (teachers, parents), and establish a human-machine collaboration mechanism where AI assists and humans lead, preventing technological alienation from replacing the core role of humans. The core functions of AI include data collection, emotional assessment, strategy generation, and outcome monitoring, serving as a tool to provide precise support for teachers and parents, reducing repetitive tasks. Teachers and parents, as the core providers of emotional support, assume leading roles, responsible for implementing intervention strategies, providing emotional companionship, and making flexible adjustments. Teachers optimize AI recommendations based on teaching experience and develop personalized plans for specific emotional issues, while parents, relying on parent-child emotional bonds, make intervention strategies more empathetic and dynamically adjust interaction methods based on children's responses. Establish a human-machine collaborative training system to enhance the ability of teachers and parents to use AI tools, clarify the boundaries of AI usage (such as not relying on AI to replace face-to-face communication and not collecting excessive private data), ensure that technology serves the core goal of emotional support, and achieve an organic unity of technological precision and humanistic warmth.

4.2. Dynamic evaluation and feedback mechanism

Construct a dynamic mechanism of real-time feedback-periodic evaluation-continuous optimization to ensure the adaptability and sustainability of emotional support. In the real-time feedback phase, teachers and parents promptly record the intervention implementation process and children's emotional changes through the AI system, and the AI conducts real-time analysis of the data. If the intervention is found to be ineffective (e.g., repeated negative emotions in children), adjustment suggestions are immediately pushed. In the periodic evaluation phase, evaluation reports are generated every 1–2 months by combining children's emotional development data and feedback from home and school, comparing intervention goals with actual outcomes, and identifying strengths and weaknesses. In the continuous optimization phase, intervention strategies and model parameters are adjusted based on evaluation results, and data collection dimensions are updated to enable the support model to dynamically adapt to children's emotional development characteristics, forming a closed loop of implementation-feedback-optimization.

4.3. Ethical standards and privacy security protection

Preschool children's emotional data involves privacy and personality rights, necessitating the construction of a comprehensive ethical and security protection system. In terms of ethical norms, three major principles are clearly defined: the principle of informed consent, which requires obtaining written consent from guardians

before collecting children's emotional data and clearly specifying the scope and purpose of data use; the principle of minimum necessity, which involves collecting only core data related to emotional development and refraining from collecting excessive private information (such as family privacy and physiological data); and the principle of non-maleficence, which aims to prevent harm to children's physical and mental health caused by data breaches or improper interventions, and prohibits the use of emotional data for commercial purposes. Regarding privacy and security, dual safeguards of technology and management are employed: At the technological level, data is encrypted and stored, anonymized, and a hierarchical access control system is implemented to prevent data breaches. At the management level, a data management system is established to define the processes and responsible entities for data collection, storage, use, and destruction, and regular data security audits are conducted. Additionally, a dispute resolution mechanism is established to clarify the handling procedures and compensation plans for issues such as data breaches and ethical disputes, thereby safeguarding the legitimate rights and interests of children and parents.

5. Conclusion

Artificial intelligence technology offers groundbreaking solutions for supporting the emotional development of preschool children. The innovative support model constructed in this paper achieves a deep integration of technological empowerment, educational principles, and family needs, resolving multiple dilemmas of traditional models. However, it must be emphasized that technology remains an auxiliary tool, and human-machine collaboration and humanistic care constitute the core essence of emotional support, with ethical norms and privacy protection serving as the bottom line for the sustainable operation of the model. Future research can further expand the sample scope, optimize the personalized adaptability of the emotion recognition model, explore the adaptability of intervention strategies under different parenting styles, and continuously improve the home-kindergarten collaboration mechanism. It is hoped that this study can provide references for the practical innovation of emotional development support for preschool children, promote the standardized and high-quality application of artificial intelligence technology in the field of preschool mental health education, and build a more targeted, warm, and scientific emotional development support ecosystem for preschool children.

Disclosure statement

The author declares no conflict of interest.

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