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IMPLICATION OF ARTIFICIAL INTELLIGENCE (AI) IN EARLY CHILDHOOD EDUCATION (ECE): A CRITICAL REVIEW OF LITERATURE

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ABSTRACT
The research explores the implication of artificial intelligence (AI) in early childhood education (ECE): A critical review of literature. The advancement of AI technologies has introduced tools capable of automatically customizing learning experiences to fostering children cognitive, social and emotional development. AI has the potential to revolutionize early childhood education by facilitating personalized assistance and enhancing learning engagement prior to primary education. The study explores theoretical frameworks of digital native proposed that child are surrounded by electronic gadgets and information technology and always in contact with computers, video games, mobile phones, and other hi-tech devices. In addition, AI in early childhood education platforms such as PopBots Platform, talking toys, YouTube Kids etc. AI helps to improves children educational experiences, benefit educators in envisaging pupils' performance, endorsing educational materials and systematizing evaluation through intelligent systems. However, challenges such as Infrastructure facilities remain one of the most significant obstacles for implementation of AI in early childhood education were noted. Finding revealed that AI-based tools significantly improve early childhood education literacy and numeracy while offering tailored learning experiences. The study recommended that AI specialist educators or teachers need to be train and retrain to build capacity for effectively integrating AI tools into classrooms, ensuring that educators can maximize the benefits of AI in teaching and learning.

Key words: Early Childhood Education, Artificial Intelligence (AI)

Introduction

Education is the responsibility of the government in a country where Nigeria is not excluded; it is the basic foundation and bed rock of any meaningful human development such as social, physical, economic or emotional. The technological development of society brought on by Artificial Intelligence (AI) has increased the future foundation of educational development in Nigeria. It is critical to develop the next generation's AI competencies and educate our children with the use of AI. Education is a solid basic foundation which serves as a means for cognitive, social, physical, economic or emotional development of a child. ECE is a good foundation for a lifelong education for sustainable national development. It is the basic building block for language learning and literacy formation during early childhood education period before children get to primary school education. Early Childhood Education is a common and widely practiced in most communities in Nigeria; mostly many individuals make provision for early childhood education programs as entrepreneurs.

Concept of Early Childhood Education (ECE)

Early Childhood Education (ECE) according to FRN (2012) refers to early childhood care and education (pre-primary education) as an education given in an educational institution to children aged 3-6 prior to their enrollment in the primary school. Early Childhood Education (ECE) is the education given in preparation for primary education in a formal school to children within age ranges of 3-6 years as a foundation for other levels of education which include: crèche, the nursery and the kindergarten. These types of education settings are currently and mostly provided by private individual, organization or entrepreneurs (Obiweluozor, 2014). Early childhood education is aimed at promoting functional and holistic development of children's cognitive functioning from birth to age 6. Early childhood education is any group programme that is designed to promote children's cognitive/intellectual development, socio-emotional development, language development, physical development, economic development and learning development from birth to age 6. Early Childhood Education is flexible in structure with baby-friendly and learner-friendly environment with adequate infrastructure specialist for these particular ages without harming them, as they are in fragile ages that need care of older individual as a teacher and care-giver.

Objectives of Early Childhood Education

The operational objectives of pre-primary education as stated in the National Policy of Education (FRN 2012) include:

i. Effecting a smooth transmission from the home to the school. Early exposure of child to AI cultivates technological fluency, numbering, preparing children for formal school environment and a world is increasingly driven by technology. It show that children who engage with AI early on are more likely to pursue STEM fields and develop digital literacy skills that are crucial for future employability.

ii. Preparing the child for the primary level of education. AI technology can foster early childhood education for cognitive, social and emotional development as foundational skills in reasoning, communication, and emotional regulation for primary education.

iii. Providing adequate care and supervision for the children while their parents are at work. With the help of AI, these applications such as ABCmouse Endless Alphabet, Montessori 123, YouTube Kids in crèche can adjust the level of difficulty according to the child's ability, making the learning experience more personal and effective while their parents are at workplace.

iv. Inculcating in the child the spirit of enquiry and creativity through the exploration of nature and environment, art, music and playing with toys, etc; AI's impact on children is vital for addressing equity and inclusivity in education.
v. Develop a sense of co-operation and team spirit. AI has the potential to bridge gaps for marginalized groups by providing accessible, personalized learning experiences (Das et al., 2025). For children with disabilities, AI-driven tools such as adaptive interfaces and virtual assistants offer tailored support that enhances their educational opportunities.
vi. Inculcating social norms; AI and early childhood development is not only beneficial but necessary. It equips children with foundational social skills and norms, prepares them for technological advancements, and fosters inclusive learning environments.
vii. Learn good habits, especially good health habits. AI-based tools like emotion intelligent recognition systems enable children to practice empathy and social interaction in structured environments, which are essential for good health habits and lifelong learning in classroom.
viii. Teaching rudiments of numbers, letters, colours, shapes, forms etc. through play. AI systems, such as interactive robots and adaptive learning platforms, can support these developmental milestones for children to identify numbers, letters and colour by providing personalized feedback and fostering problem-solving skills in classroom.

Benefits of Early Childhood Education (ECE)

Early childhood education is identified with many benefits which, according to Yisa, *et al.* (2017); Taguma, *et al.* (2012) include achieving adequate child welfare, strong social and economic base for lifelong learning. There are numerous benefits of early childhood education, it has received the attention of the world and seen by policy makers as a way of achieving a base for lifelong learning as well as obtaining support for the educational, development and social needs of the children. The benefits of ECE which includes development of mental functions of a child in areas of language, motor skills, psychosocial, cognitive and learning skills (Sani, *et al.*, 2017; Bowman, *et al.*, 2001). It has developed children's school readiness with positive economic and social impacts (Sani *et al*., 2017). In addition, Sooter (2013) states the aims of ECE to include fostering proper development of children, identifying and addressing their problems, harnessing their potentials, molding their characters, enhancing their learning and equipping them for life so that their actions are channeled towards positive personal, communal and global development. It is pertinent to note that all ECE activities and programmes are geared towards giving positive early experiences to children.

Early Childhood Education can lay a foundation for gender equality (Sani, *et al.,* 2017). A well designed early childhood education has a potential of challenging gender stereotypes in the society. Also, early childhood education school helps bring equality for both boys and girls. Early childhood education benefits the child for his greater potentials to be unveiled in a social, economic and parental benefit which will in turn have a positive impartation for the nation's transformation agenda in education and social development. Early Childhood Education benefits children with disability, which can help to identify any psychological problems at early stage and increase the possibility for provision of treatment.

Concept of Artificial Intelligence

Artificial intelligence (AI) has emerged as a transformative force in various fields, including Early Childhood Education. AI is refers to computer systems that perform tasks, usually associated with human minds, particularly learning and problem-solving (Baker & Smith, 2019). AI according to Mondal (2020) is the science and engineering of devising smart systems that use machine learning, neural networks, and natural language processing to solve a

variety of problems. AI is a branch of computer science that combines machine learning, algorithm development, and natural language processing (Akgun & Greenhow, 2021). This broad definition of AI allows us to encompass multiple functions of AI. Collins *et al*. (2021) provide sourced descriptions of some of the important functions of AI, which at least provide a framework of the ways AI could be used. These functions include but are not limited to: AI as Expert Systems, AI as Machine Learning, AI as Robotics, AI as Natural Language Processing, AI as Machine Vision, and AI as Speech Recognition (Campbell & Cox, 2024). Artificial Intelligent is used in reshaping the educational landscape as simulation of human intelligence processes by making use of machines, including personalized learning, reasoning, problem-solving, and decision-making for early childhood education. Some applications of Al in early childhood education are visual mentors, voice assistants, taking toy, presentation translators, automatic assessments, personalized learning and educational words wall and letter games.

Concept of Artificial Intelligence and Early Childhood Education (ECE)

The "artificial intelligence education" involved in this article mainly refers to the ability to apply artificial intelligence technology to the enlightenment teaching of AI science for young children, and to make education informalization (Wang *et al.,* 2023). AI tools are increasingly being used in the field of early childhood education (ECE) to enhance learning and development among young children (Lin *et al*., 2020).

AI technology for scientific research gradually popularized into human daily life, in response to the current situation, in the rapid development of artificial intelligence technology, human attention to early childhood education gradually increased. The new AI-enabled interfaces that support interaction through gesture, touch, and speech allow children to access digital content and services. AI enabled devices, such as smart toys need to be provided to children in a constructive and safe manner in order to avoid any injuries while in contact with materials.

Today's children encounter AI in the forms of smart toys, smart tablet, and computationally curates educational and entertainment content. Children growing up in the era of AI will have fundamentally different relationships with smart technologies than those who first encountered AI later in life (Williams *et al*., 2019). There is an increasing excitement concerning the potential of artificial intelligence and transformation of ECE. The rapid development and advancement of technologies such as social media, smart-phones, tablet and wearable devices has enabled educators in the ECE field to quickly access vast amounts of data AI as a computational technology mimicking human intelligence, utilizes advanced algorithms to automatically learn from this data, making it easier and more accurate to identify individualized data patterns for learning and make precise predictions from massive multidimensional data (Chen *et al*., 2024). AI technologies have played a significant role in various fields such as robotics, image and speech recognition and natural language processing (Xiang *et al*., 2020).

One example of artificial intelligence education is PopBots Platform and Curriculum consists of social robot toolkit, three hands-on AI activities, and associated assessments for young children to explore machine learning, reasoning, and generative algorithms. Williams *et al*. (2019) PopBots is a hands-on toolkit and curriculum designed to help young children learn about AI by building, programming, training, and interacting with a social robot. The PopBot Components are social robot which is made of a smart-phone, LEGO blocks, motors and sensors. The blocks based programming interface resides on a tablet, on platform of an Android phone with the PopBot app, a tablet with the PopBlocks app, a LEGOWeDo 2.02 set with motors, and LEGO blocks for all ages of children at pre-primary and primary education level.

Today, a number of platforms exist for children ages 2+ including robots, educational apps, websites, board games, and hardware as that a child can hold, touch, see, and feel using his or her senses. Through different mediums, children learn computational thinking ideas (e.g., sequencing, conditionals, decomposition, etc.) by playing games, shading objects, solving puzzles and creating art without necessarily knowing the implications of what they are doing. There are a number of design cues from these learning-to-code systems to develop our early AI curriculum (Williams *et al*., 2019). According to Resnick (2017); Williams *et al*. (2019) the PopBot Design was built on constructionist ideas into our AI curriculum because this is the most effective way to help young children learn. The four principles underpinning our designs are:

i. Hands-on learning. These make the toolkit interactive and let children guide themselves through activities.
ii. End-to-end learning. The children play a role in every step of developing a full system, from training to operating a fully functional system.
iii. Transparency and thinker ability. This involving choose algorithms and give feedback that exposes as many logical and reasoning steps as possible.
iv. Creative exploration. These embed the AI algorithm in fun and creative activities. Give children agency to make something personally meaningful.

Therefore, the AI curriculum is increasingly being included into 21st century computing. Two AI tools are PopBots and Zhorai have been used to design AI curriculum for ECE, helping young children understand the concept of AI or machine learning more easily (Lin *et al*., 2020; Williams *et al.,* 2019). Firstly, the teaching method of the PopBots had indicated a positive impact on young children's learning. Secondly, children's participation rate had increased when learning machine knowledge via the conversational aspect of teaching children (Lin *et al*., 2020). According to Chen *et al*. (2024) found that there are several major AI applications in education, such as intelligent tutoring systems for special education, natural language processing for language education, educational robots for AI education, educational data mining for performance prediction, discourse analysis in computer-supported collaborative learning, neural networks for teaching evaluation, affective computing for learner emotion detection and recommender systems for personalization. Liu and Hwang (2025) investigated the use of touch-screen mobile devices in ECE. They revealed that the most common application of AI technology in ECE was the use of touch-screen mobile devices to assist young children in developing their language skills.

Artificial Intelligence Literacy in Early Childhood Education (ECE)

According to Long and Magerko (2020), AI literacy refers to a collection of skills that enable humans to analyze, interact with, and utilize AI as a tool in various settings, such as online, at home, and in the workplace. The introduced "AI literacy" was used to highlight how important it is for everyone, especially early childhood education to incorporate AI into their digital literacy (Ng *et al*., 2021). AI has become vital literacy ability for every person, even young learners, to recognize and apply AI to learn and work in this digital era (Steinbauer *et al*., 2021). Toys driven by AI are intended to teach children how to code while providing them with an enjoyable opportunity to interact with and learn about robotics and kits. By creating more carefully crafted AI toys and services, young learners may be enabled to attain AI literacy even at the KG level (Shubham *et al*., 2023). To learn about issues connected to AI, including;

i. Natural Language Processing (NLP), these involve interaction between computers and a child using chatbots designed for language teaching, robotic kits used for learners and intelligent tutoring systems such as sentiment analysis, text classification and entity recognition that can help special

education learners (Shubham *et al*., 2023; Yang, 2022). It has enhanced children's reading, creative, emotional-regulation, cooperative learning, and computational thinking skills.

ii. Neural Networks: it used as model and simulation of human cognition and behaviour, it involve speech recognition or natural language processing, e. g talking toy, game tablet etc. AI tools are increasingly being used in early childhood education to enhance the learning and speech development of children using child-friendly AI robots in language processing.

iii. Knowledge-based systems, involve information about how to solve problems then use that information to make decisions, such games, letters arrangement, arithmetic etc. AI can also provide meaningful and more efficient learning experiences, provide early knowledge related to digital use for children, and make the learning process more interactive and adaptive.

iv. Supervised machine learning, involves acquiring a knowledge base encounter through personalized recommender systems for media streaming applications such as YouTube Kids, Kiddies Learning App. Introducing machine learning through age-appropriate activities ensures that children develop confidence and curiosity in engaging with technologies

v. Generative AI, involve children using robots like (Quickdraw and PopBots) improves creativity in learning rules, the system Generates a new output based on children's input song, camera apps, melody by changing the tempo and progression with emotions to teach musical emotions to the robot (Williams *et al*., 2019). AI is strongly looked at teaching machine learning to children using AI robots which the mental development.

Benefits of Artificial Intelligence in Early Childhood Education (ECE)

In early childhood education, teachers and care-givers are able to plan, organize, compare and synthesize disparate sources, as well as create new material such as computer code, art, and even optimal personalized study schedules. AI can also analyze primary data on an individual student's academic performance and can suggest tailor-made approaches, interventions, and alternate learning avenues to meet their specific need (Bell, 2021).

AI can be used to improve students' educational experiences; it can benefit educators in envisaging pupils' performance, endorsing educational materials, and systematizing evaluation through intelligent systems (Durrani *et al*., 2024). However, to facilitate thorough and deep information processing, facilitators may need to re-design tests and assignments to ensure that requisite activities for learning are not bypassed. Further, developing assignments that integrate benefits of AI and limit risks will require assignments that demand more than simple regurgitation of facts. AI can enable new forms of learning interaction, that can help teachers to address variability in children learning, support adaptively, enhance feedback loops, support teachers and importantly, it can increase the chance of identify risks and create a way of addressing the risks that have not yet been considered.

AI-based tools could theoretically enhance the work of trained human teaching and non-teaching staff (Bell, 2021). For instance, currently available AI technologies could be used to automate some of the time and labour-intensive aspects of classroom practice and thereby stimulate gains in efficiency of and access to educational services in both public and private sectors.

Everybody will need to consider privacy and data security when using AI, as it is a term denoting a category of tools; it has no morals to direct its development or actions. Above all children using AI apps, needs to be more focus on how vital it is for them to acquire AI literacy and the implications that go along with it. They make use of AI-powered goods, such as recommendation engines and chatbots, to make their daily life and academic pursuits easier (Gaube *et al*., 2021).

AI curriculum is increasingly being included into 21st century computing, which have been used to design AI curriculum for ECE, helping young children understand the concept of AI or machine learning more easily. The teaching method of the AI had indicated a positive impact on young children's learning. The children's participation rate had increased when learning machine knowledge via the conversational aspect of the AI platform. It promotes the creation and effectiveness of systems, which are obviously very useful educational tools. AI tools are shown to improve teaching quality of teachers and the efficacy of teaching languages to children. AI tools including smart robots can enhance social interactions among children; making children more participated in learning activities (Druga *et al*., 2019; Kewalramani *et al*., 2021).

Digital Native Theory of Artificial Intelligence

The theory of Digital native was grounded to guide this article; Digital native was propounded by Marc Prensky (2001). Digital natives (or net generation or millennial or Google generation) refers to the children raised in a digital, media-saturated world. It may also apply the young generation of learners who are "native speakers" of the digital language of computers, videos, video games, and social media. The theory refers to those who were born in the era of new digital and information technology. Digital natives have grown up surrounded by electronic gadgets and information technology and they cannot do without computers, video games, mobile phones, and other hi-tech devices. The theory has become popular among parents who clash with their children at home over internet technology issues such as gaming, texting, YouTube, Instagram, WordPress, (Matthew, *et al* 2017). Digital natives are children who are exposed to the digital culture, who are born and are more vulnerable to the digital era. Digital natives are assumed to be inherently technology-savvy (Prensky 2001; Wang *et al.,* 2023). In this regard early childhood education has become more important in digital natives. Thus, the new digital media expose children to a changed in learning culture and learning behaviour, through intensive use of information and communication technology using electronic gadgets in learning.

Challenges of Artificial Intelligence in Early Childhood Education (ECE)

i. Infrastructure facilities remain one of the most significant obstacles for implementation of AI in early childhood education. Many schools, particularly in rural areas, lack basic technology, such as stable internet access and electricity, which are essential for AI implementation in early childhood education.
ii. It involves deploying a technology that requires a high level of specialist knowledge (technical knowhow) in order to comprehend/communicate risks/benefits. Teacher preparedness is a major challenge, many educators are not adequately trained to integrate AI into their teaching practices, leading to reluctance in adopting new technologies.
iii. Uninterrupted power supply that are needed to power AI gadgets and other ICT appliances. The power supply has been major setbacks that hinder the widespread adoption of AI in early childhood education leading to reluctance in embracing the technology.
iv. AI resources that are relevant to ECE at pre-primary school level are not adequately provided either by public or private centers'. Resources constraint faced by early childhood education program in procuring AI tools and devices and most pre-primary schools operate on limited budgets, making it difficult to invest in the latest educational technologies.
v. Limited availability of data for training and evaluating AI models which include data augmentation, transfer learning and active learning to make the most of the available data. Unavailability of data for AI has hindered the teaching and learning of AI technologies in early childhood education centres.

Way forward of Artificial Intelligence in Early Childhood Education (ECE)

i. AI specialist educators or teachers need to be train and retrain to build capacity for effectively integrating AI tools into classrooms, ensuring that educators can maximize the benefits of AI in teaching and learning.
ii. Government should provide funding for AI infrastructure in pre-primary and primary schools, ensuring that technological tools are available and accessible to both teachers and pupils, particularly in underserved areas.
iii. Data availability should be ensured for learning necessary skills, resources to manage and protect the data used during learning process through AI.
iv. The *use* of peer-to-peer and collaborative learning strategies to improve instructional design for children through the preparation, support and development of learner's abilities.
v. Availability of power supply to ensure proper utilization of AI facilities, and also provision of power backup solutions in case of power failure in pre-primary and primary schools.

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