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Research on the Core Composition and Development Path of Digital Literacy of Kindergarten Teachers in the Intelligent Era

Danping Li*

Philippine Christian University, Manilla, 1004, Philippines
**Corresponding author*

Abstract: *With the rapid development of artificial intelligence, big data, Internet of Things and other smart technologies, the field of education has ushered in profound changes. Kindergarten education, as the foundation stage of individual lifelong development, its digital transformation puts forward brand-new requirements for teacher literacy. Focusing on the context of the smart era, this study analyses the core components of kindergarten teachers' digital literacy and proposes a three-dimensional framework that covers five dimensions: technology application, data thinking, pedagogical innovation, ethical safety, and lifelong learning. On this basis, we systematically explore the multi-dimensional and synergistic development paths of policy support, institutional training, garden-based practice, and teachers' self-development, with the aim of providing theoretical references and practical guidance for improving kindergarten teachers' digital competence and promoting the high-quality development of preschool education.*

Keywords: *Intelligent Era; Kindergarten Teachers; Digital Literacy; Core Composition; Development Path; Preschool Education*

1. Introduction

We are in an era marked prominently by smart technologies. The deep integration and wide application of technologies such as Artificial Intelligence (AI), Big Data, Cloud Computing, Virtual Reality (VR/AR), and Internet of Things are reshaping every aspect of social production and life at an unprecedented speed, and the field of education is no exception. As the starting point of the national education system, pre-school education carries the important mission of laying the foundation for individual lifelong learning and development. Intelligent technology has brought unprecedented opportunities to kindergarten education: personalized learning support, immersive context creation, accurate process evaluation, and efficient home and family co-education have become possible. However,the empowerment of technology is ultimately realized by teachers. Whether kindergarten teachers, as the direct bearers of educational practices, have digital literacy to meet the requirements of the smart era is a key variable that determines the success or failure of the digital transformation of preschool education.

At present, the overall level of kindergarten teachers' digital literacy varies, and there are problems such as superficial application of technology, weak data awareness, insufficient innovation and integration ability, unclear understanding of ethical risks, and lack of motivation for continuous learning. Therefore, it is of great theoretical significance and urgent practical need to systematically study the core components of kindergarten teachers' digital literacy in the age of intelligence and explore scientific and effective development paths. This study aims to respond to this proposition of the times and provide theoretical support for the construction of kindergarten teachers and the improvement of preschool education quality.

2. The connotation and core composition of digital literacy of kindergarten teachers in the age of intelligence

Digital literacy has evolved from the simple ability to acquire information and operate tools in the early days to a comprehensive literacy to work, learn, live, communicate and think critically effectively in a digital environment [1]. In the educational scenario of the smart era, the digital literacy of

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kindergarten teachers has been given a richer and deeper connotation: it refers to the safe, appropriate, effective, innovative and ethical use of all kinds of digital technologies and data resources based on the understanding of the nature and educational value of smart technologies, to optimise the process of teaching and learning, to support the holistic development of young children, and to promote the growth of professional autonomy, Strengthen the comprehensive ability and attitude of collaborative parenting at home.

Based on a comprehensive analysis of the characteristics of smart technologies, the laws of preschool education, and teachers' professional standards, this study proposes five core constituent dimensions of kindergarten teachers' digital literacy.

First, smart technology tool application and operation literacy. First, basic hardware and software operation ability refers to the proficient use of hardware such as intelligent interactive whiteboards, tablet PCs, educational robots, AR/VR devices, and intelligent recording and broadcasting systems, as well as common operating systems, office software, resource platforms, and management tools [2]. Secondly, intelligent education software/platform application ability requires mastering the functions and application scenarios of educational APPs, online learning platforms, AI interactive courses, digital picture books, programming enlightenment tools, etc., which are suitable for young children's age characteristics. Finally, the ability to solve technical problems means being able to diagnose and solve common equipment failures, software conflicts, network connections, and other problems to ensure smooth teaching activities.

Second, educational data awareness and interpretation literacy. Data sensitivity and collection awareness are very important, understanding the value of data in observing and evaluating young children and optimizing teaching decisions, and being able to take the initiative to use smart devices (e.g., wearable devices to monitor movement, emotion recognition systems), online platforms, and digital observation and recording tools to collect data on young children's behaviours, development, and interests. Data comprehension and analysis ability refers to the ability to use visualisation tools or analysis functions provided by the platform to interpret early childhood development assessment data, activity participation data, learning trajectory data, etc., to identify patterns, discover problems, and gain insight into individual differences. Data-driven decision-making ability is the ability to adjust teaching plans, activity design, environment creation, and individualized support strategies based on the results of data analysis, so as to achieve precise teaching [3].

Third, instructional design and innovation literacy are supported by intelligent technology. The meaning of technology-integrated instructional design ability is to naturally and appropriately integrate into the design of instructional activities in the five domains (health, language, social, science, and art) as a cognitive tool, an expressive tool, a contextualisation tool, a collaborative tool, and an evaluative tool, etc. [5], which serves specific educational goals (e.g., using VR to conduct virtual investigations, using programming robots to develop logical thinking, etc.). programming robots to develop logical thinking.

Personalized learning support capability, which refers to the use of technologies such as AI recommendation systems and adaptive learning platforms to provide personalized learning resources, pathways and challenges for young children with different developmental levels and learning styles. The ability to explore innovative teaching modes refers to experimenting with new teaching modes such as project-based learning (PBL), gamified learning, and blended learning (combining online resources with offline activities), and using technology to expand the depth and breadth of learning.

Fourth, digital security, ethics, and responsibility literacy.

Firstly, one should have the ability to protect the information security of young children, which means strictly abiding by relevant laws and regulations (e.g., Personal Information Protection Law, Regulations on the Network Protection of Children's Personal Information), and being proficient in methods of data encryption, permission setting, and safe storage, to ensure the absolute security of young children's personal information, images, and activity data. Secondly, the ability to make ethical judgement about the use of technology refers to the ability to identify and avoid potential risks in the use of technology (e.g., over-reliance on screens, algorithmic bias, privacy leakage, information cocooning), and to ensure that the use of technology is in line with the laws of young children's physical and mental development and educational ethics (e.g., balancing the virtual and real experiences). There is also the awareness of digital citizenship, which refers to the permeation of activities with digital citizenship education content such as preliminary online behavioural norms, information discernment awareness, and healthy eye habits, in order to lay the foundation for young children's future digital life. Finally, there is the norms of digital communication at home, which refers to following the principles of professionalism,

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appropriateness and confidentiality when using tools such as classroom groups and home-based co-education platforms to build a harmonious and mutually trusting digital home relationship.

Fifth, professional development and lifelong learning literacy.

The implication of the ability to learn with digital resources is the proficient use of online courses (MOOCs), professional communities (e.g., learning communities, web-based workshops), academic databases, high-quality public numbers, knowledge-sharing platforms, etc. to acquire cutting-edge knowledge, teaching resources and practical experience. It also includes the ability to collaborate and share knowledge online, actively participate in activities such as online teaching and research, cross-regional experience exchange, and resource sharing, and utilise technology to enable the connection and co-creation of professional communities (European Commission, 2019). There is also a technologically supported reflection and research capacity to document teaching practice, reflect, conduct small-scale action research and promote evidence-based practice using blogs, e-portfolios, data analysis tools, etc. Not to be overlooked, of course, is the willingness for continuous learning and adaptability. Maintain curiosity, openness and motivation for continuous learning about emerging smart technologies and their educational applications and actively adapt to the rapid iteration of technology.

These five dimensions are interrelated and supportive of each other and together constitute a digital competency base for kindergarten teachers to effectively carry out educational work and achieve professional development in the age of intelligence.

3. The Dilemma of Kindergarten Teachers' Digital Literacy Development

Although the importance of improving digital literacy has become a consensus, the current development process still faces many challenges, as follows:

First, cognitive bias and insufficient intrinsic motivation. Some teachers are intimidated by or resistant to smart technologies, believing that they are "unfathomable" or "burdensome", and failing to deeply understand the value of technology in improving the quality of education and emancipating teachers' productivity. They are satisfied with basic applications and lack the internal drive for in-depth exploration and innovation.

Second, systematic training and support systems are lacking. In addition, the pre-service training is weak [4], the relevant curriculum in teacher training colleges is lagging behind, the content is outdated, there is a lack of integration with real kindergarten scenarios, there are few opportunities for practice, the post-service training is fragmented, and the content of the training is often biased in favour of the operation of the tool ("how to use it"), neglecting the integration of the educational scenarios ("why to use it"). "Why to use" and "how to use it well"), data thinking, ethical safety and other deep literacy. The training is in a single form and is not sustainable, systematic and targeted. Insufficient support from kindergartens. Some kindergartens lack the necessary intelligent hardware facilities and a stable and high-speed network environment. The improvement of digital literacy has not become a core topic in school-based teaching and research, and there is a lack of effective incentive mechanisms.

Third, there is a lack of high-quality and suitable resources and difficulties in integration: There is a relative lack of kindergarten intelligent education software/resources on the market that are in line with the cognitive characteristics of young children, highly educational and well-designed, and the quality of the software/resources varies. Teachers do not have enough time and energy to screen, evaluate, and effectively integrate and utilise these resources.

Fourth, digital ethics and security challenges are highlighted: As the application of technology deepens, ethical issues such as how to ensure data privacy and security for young children, guard against the risk of technological dependence, identify and cope with algorithmic bias, and strike a balance between the virtual and the real are becoming more and more prominent, and teachers' related awareness and handling skills need to be strengthened.

Fifth, uneven regional and individual development should be enforeced. There are significant gaps in hardware facilities, access to resources, and training opportunities between economically developed regions and less developed regions, and between urban and rural gardens. The digital literacy gap between individual teachers due to age, professional background, interest, etc. also exists objectively.

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4. Multidimensional Paths for the Development of Kindergarten Teachers' Digital Literacy

To break the dilemma and improve the digital literacy of kindergarten teachers, it is necessary to build a systematic support network with multiple synergies and multiple paths, as follows:

First, policy leadership and standard construction should be advocated. They are incorporated into national/local teacher standards, and when revising the professional standards for kindergarten teachers, explicitly take digital literacy in the age of intelligence as one of the core competencies and refine the specific requirements of each dimension Ministry of Education, 2012). They also formulate a special development plan. The education administration department should issue a special plan or action plan to improve the digital literacy of kindergarten teachers, with clear objectives, tasks, and safeguards. They should improve resource allocation and protection, increase investment in kindergarten informatisation infrastructure (especially smart terminals, networks, and platforms), and tilt it towards weaker areas. Setting up special funds to support teacher training and resource building is necessary. They should establish a certification and incentive mechanism and explore the inclusion of digital literacy levels as a reference basis for regular registration of teachers' qualifications, appraisal of titles, and evaluation of excellence, so as to stimulate teachers' motivation to learn.

Second, the pre-service and post-service integrated training system should be reconstructed. It is necessary to strengthen the training in teacher training colleges, reform the curriculum system, and add informatisation of pre-school education, application of intelligent technology in education, foundation of educational data analysis, digital ethics, and other compulsory or core courses (Starkey, 2020). Strengthening case teaching, project-based learning, simulation, and practical training, and building smart education training rooms. It should be encouraged to build practice bases with quality kindergartens to strengthen the practical aspects. Optimizing the post-service training system with upgraded content, shifting from pure skills training to comprehensive literacy enhancement, integrating educational concepts, technology integration, data thinking, and ethical reflection are crucial. It is enhanced to develop training programmes that are categorized into different levels (e.g., novice teachers, core teachers, administrators). Mode innovation: Teachers should adopt various forms such as online-offline integration (OMO), workshops, master teacher workshops, school-based training, action learning, peer support, online community, etc. to enhance interactivity, practicability, and sustainability. AI technology is used to provide teachers with personalized learning recommendations and coaching. kindergartens are encouraged to take digital literacy enhancement as the core theme of kindergarten-based teaching and research, and focus on real teaching problems (e.g., "How to use tablets to support children's exploratory learning?", "How to use tablets safely and effectively to support children's learning?").

Third, empowering the main platform of garden practice is necessary. It refers to building an intelligent, nurturing environment, actively introducing suitable intelligent education technology equipment at the garden level (no need to pursue high-end, focus on applicability), and creating an atmosphere that encourages technological exploration and innovation. It can create a learning community,establish a "digital literacy enhancement group" led by key teachers or information specialists, and organise activities such as technology salons, teaching observation, and case sharing to promote peer learning.

Establishing a mechanism for resource sharing and encouraging teachers to collect, develop, and share excellent cases of smart technology applications, teaching designs, and resource packages are crucial. Parks establish digital resource libraries and manage them effectively. They can provide continuous technical support with full-time or part-time information technology personnel to promptly solve technical problems encountered by teachers in daily use and eliminate worries. Leadership attention and institutional guarantee: Campus directors need to take the lead in enhancing their digital leadership, incorporating digital literacy development into campus development planning and teacher development planning, and providing support in terms of time, funding, and evaluation.

Fourth, teachers' internal drive for independent development should be stimulated. A lifelong learning perspective should be established: Teachers need to be deeply aware of the irreversibility of the development of intelligent technology and its reshaping effect on the shape of education, and regard the enhancement of digital literacy as an inevitable requirement and an intrinsic need for professional development. They should enhance information acquisition and discernment, take the initiative to pay attention to the cutting-edge development of education technology, and use authoritative platforms and channels to obtain information. Teachers need to enhance their ability to screen, evaluate, and critically absorb massive amounts of information. They should be courageous in practice and reflection, boldly and cautiously trying to apply new technologies in teaching, recording the process, reflecting on the

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effects, and summarizing the lessons learnt. They need to start small and go deeper step by step, and actively participate in professional communities. They need to join online and offline professional learning communities (e.g., educational technology-related associations, forums, and microblogging groups) to communicate and discuss with peers and experts, expand horizons, and solve puzzles. They also need to carry out reflection and research on technical support, use blogs, electronic notes, data analysis tools, etc., to record educational narratives, reflect on teaching, and even carry out research on small topics to achieve theoretical enhancement of practical wisdom.

Fifth, a social support ecology should be bulit. Universities/research institutes support university researchers to go into kindergarten practice, provide theoretical guidance, project cooperation, evaluation,and consultation services, and help kindergartens to solve the deep-rooted problems in the application of technology. Fulfilment of corporate social responsibility: Educational technology enterprises should develop products and services that better meet the actual needs of kindergartens, are easy to use, have high educational value, and are safe and compliant (UNESCO, 2023). Provide quality teacher training and technical support. Avoid excessive marketing and exaggerated publicity. Bridging role of professional organisations: Organisations such as the Society for Preschool Education and the Association for Educational Technology build communication platforms, hold seminars, competitions, promote excellent cases, and formulate industry guidelines (e.g., ethical codes of practice for the application of smart technologies in kindergartens). Collaborative parenting between home and family: Promote to parents the purpose, methods, and safety measures of technology application in kindergartens, guide parents to form a rational understanding, and work together to cultivate young children's healthy digital life habits.

5. Conclusion

The wave of intelligent technology is constantly rushing, profoundly reshaping the shape and future of education. As the initial guide of young children's growth, the digital literacy level of kindergarten teachers is directly related to whether they can grasp the opportunities of the times, create a more supportive, inspiring and personalised learning environment for young children, and effectively promote their comprehensive and harmonious development European Commission, 2019). The five core dimensions (technology application, data thinking, pedagogical innovation, ethical safety, and lifelong learning) proposed in this study outline a digital competency map for kindergarten teachers in the smart era. To solve the current development dilemma, it is urgent to build a multi-dimensional and three-dimensional development pathway system with the concerted efforts of policies, institutions, kindergartens, teachers themselves and social forces. Enhancing the digital literacy of kindergarten teachers is by no means a mere acquisition of technology, but a profound journey of educational conceptual renewal and practical innovation. The ultimate goal is to empower teachers to understand and support children in a smarter way, so that technology can blossom in the fertile soil of early childhood education and illuminate children's path to the future (Feng & Cai, 2017), which requires sustained attention, dedication, and intelligent exploration.

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