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Article

Generative AI as a Digital Scaffold for Novice Teachers: Opportunities and Challenges in Kindergarten Curriculum Design in China

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Abstract: Generative artificial intelligence (GenAI) is rapidly integrating into educational practices, yet its impact on teacher professional practice within the highly context and relationship-dependent field of early childhood education remains poorly understood. This study explores how GenAI functions as a "digital scaffold" to support novice preschool teachers in de-signing contextualized, kindergarten-based curriculum within the Chinese context. Through in-depth interviews and thematic analysis with 10 teachers, we discovered GenAI's dual potential: it empowers educators by providing instant re-sources and inspiration, yet its "decontextualized" outputs create tension with the contextual and relational core of early childhood education. Crucially, teachers demonstrated robust professional agency by critically evaluating and localizing AI-generated content. This process of "mediated reflection" catalyzed their professional knowledge development. Ultimately, AI integration does not replace teachers but re-configures their professional roles toward higher-value, human-centered core competencies-situational judgment, ethical decision-making, and emotional connection-which form the bedrock of resilient and sustainable educational ecosystems. Our findings underscore that responsible AI integration in education must prioritize sup-porting teacher agency and well-being to enhance systemic sustainability.

Keywords: Generative Artificial Intelligence (GenAI); digital scaffold; early childhood education; teacher agency

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1. Introduction

As the global community commits to achieving the 2030 Agenda for Sustainable Development, ensuring inclusive, equitable, and quality education (SDG 4) has emerged as a central objective [1]. Against this backdrop, the rapid advancement of digital technologies-represented by Generative Artificial Intelligence (GenAI)-is providing fresh impetus for the transformation and reshaping of the educational ecosystem [2]. Educators and researchers are actively exploring GenAI's potential applications in curriculum design, personalized learning, and other domains, striving to advance educational paradigms through technological innovation [3,4]. However, the deep integration of technology is not merely about enhancing efficiency; its deeper value lies in how it can foster inclusivity, resilience, quality, and sustainability within education systems.

Early childhood education serves as the cornerstone for building a sustainable future, with its quality directly impacting the fairness of starting points for lifelong individual development [5]. As the core practice for achieving contextualized and localized education, the sustained generative capacity of kindergarten-based curriculum is pivotal to ensuring the quality and distinctiveness of early childhood education [6]. However, this highly complex endeavor relies heavily on teachers' professional competence and

creativity. For novice teachers-the emerging force within the teaching workforce and a vital variable for sustainable development-they often find themselves trapped in a predicament of multiple shortages: professional knowledge, practical resources, and time and energy [7-9]. This not only constrains their individual professional growth but may also impact their professional identity and willingness to remain in the profession, thereby posing a potential threat to the stability of the teaching workforce and the sustainability of professional development.

GenAI offers a novel supportive pathway for this purpose. Its robust content generation and natural language interaction capabilities position it to serve as a temporary, supportive "digital scaffold", providing novice teachers with immediate resources and cognitive support to bridge the "zone of proximal development" (ZPD) in professional practice [10,11]. This metaphor accurately captures technology's role as an "adjunct" rather than a "substitute", inherently requiring teachers to serve as the ultimate "architects" exercising core responsibilities of critical evaluation and creative adaptation. However, existing research exhibits significant limitations: most studies focus on higher education or K-12 settings, often adopting a technology-centric functional approach [12,13]. They lack in-depth exploration of GenAI's role in the highly contextualized process of curriculum creation in early childhood education, particularly from the perspective of teachers' experiential agency and the sustainability of educational ecosystems [14,15].

Therefore, this study aims to explore a core issue from the perspective of novice preschool teachers: How does GenAI, as a "digital scaffold" function in novice teachers' kindergarten-based curriculum design practices? Is it an effective tool that empowers teachers' professional practice and promotes sustainable improvement in curriculum quality, or does it become a "shaky scaffold" that exacerbates practical challenges due to its inherent limitations? By deeply analyzing the human-machine collaboration dynamics within this specific context, this study seeks to provide empirical evidence and theoretical insights for the sustainable development of intelligent technologies in early childhood education. This includes enhancing teacher professional resilience, safeguarding educational quality, and promoting equity.

2. Literature Review

2.1. Applications of GenAI in Education: The Evolutionary Potential from Efficiency Tools to Interactive Partners

GenAI, with its powerful content generation and natural language interaction capabilities, is sparking extensive and profound practical exploration and academic discourse across the global education sector. Technologies represented by large language models (LLMs) such as ChatGPT and Gemini, alongside text-to-image models like Midjourney and DALL-E, are being integrated into diverse teaching and administrative contexts [16,17]. Existing research reveals two core roles GenAI plays in education.

First, GenAI is widely regarded as an efficient "production tool". It can automate a large number of routine, time-consuming tasks, significantly enhancing the efficiency of educational work [18-21]. This manifests in: (1) Curriculum and content generation: Rapidly producing syllabi, unit lesson plans, explanatory texts for key concepts, diverse quiz questions, and answer explanations. (2) Personalized learning material design: Adjusting content difficulty, style, cultural context, or examples by analyzing learner characteristics or responding to specific prompts, providing technical support for differentiated instruction. (3) Instructional activity support: Assisting teachers with lesson plan development, activity ideation, classroom scenario simulations, and even strategy recommendations. (4) Automated assessment and feedback: Performing preliminary checks on student text assignments for grammar, structure, and providing formative feedback to alleviate basic grading burdens.

Secondly, beyond mere productivity gains, GenAI demonstrates greater potential as a "creative partner" or "collaborator". Through human-computer interaction, it can

facilitate brainstorming, offer cross-disciplinary associations, present diverse perspectives or alternative solutions, and stimulate creative thinking among teachers and students. This makes it particularly well-suited for project-based learning, interdisciplinary curriculum design, and open-ended inquiry activities [22,23]. This role suggests the potential for more dynamic and inspirational interactions between GenAI and its users.

However, alongside its application potential lie widespread concerns raised by academia and practitioners. The inherent "hallucination" issue-where generated content may contain factual errors or fabricated information-poses a fundamental challenge to the authenticity of educational materials. Ethical and equity dilemmas have also come to the fore, including academic integrity crises, intellectual property disputes, the propagation and amplification of training data biases within generated content, and the potential exacerbation of educational inequality stemming from disparities in access conditions [24,25].

It must be noted that the above discussion largely applies to higher education or K-12 general subject scenarios where course objectives are relatively standardized and knowledge systems are well-defined. In these contexts, GenAI is primarily employed as a "tool" or "resource" to optimize established teaching processes. This dominant "instrumentalist" perspective emphasizes evaluating the technology's outputs (such as content quality and efficiency gains) and managing its associated risks, while relatively neglecting how the technology functions as a dynamic, adaptive mediator in complex, generative tasks-engaging in continuous, constructive interaction with users. The limitations of this theoretical perspective become particularly pronounced in the field of early childhood education, which emphasizes process-oriented, contextual, and co-constructive approaches. More critically, evaluating GenAI solely through the lens of tool efficiency prevents us from discerning whether its integration empowers or erodes the sustainability of teachers' professional practice and the educational ecosystem. Therefore, GenAI must be situated within the specific sustainable practice domain of early childhood education to examine its micro-interaction processes.

2.2. Focusing on Preschool Education and Kindergarten-Based Curriculum Development: An Interactive Domain in Need of "Process-Oriented Support"

Preschool education, particularly kindergarten-based curriculum development, possesses fundamental characteristics distinct from other educational stages. Kindergarten-based curriculum is not an external, static textbook system, but rather a dynamic process co-constructed and developed through sustained, in-depth daily interactions between teachers and children, rooted in the physical environment, cultural atmosphere, and community resources of a specific kindergarten [26,27]. This process itself constitutes the core practice ensuring education's "cultural adaptability" and "local relevance"-two critical dimensions for sustainable development-and fundamentally supports the sustainable generation of preschool education quality. The generative, contextual, and collaborative nature of this process places exceptionally high demands on kindergarten teachers' "curriculum creation capabilities": Teachers must possess keen observational skills to capture children's interests and questions; rich practical knowledge and imagination to transform fleeting points of interest into deep, explorative thematic networks; and sophisticated pedagogical wisdom to design and implement activity sequences that guide children toward active inquiry through play and daily life [28,29].

Existing research on information technology applications in preschool education exhibits a significant disconnect between its focus areas and the generative nature of kindergarten-based curricula [30,31]. Studies primarily concentrate on: (1) Multimedia and existing software applications: Exploring how educational software and multimedia resource libraries can enrich the presentation formats of established curricula or support specific domain instruction (e.g., early mathematics, language initiation). (2) Digital management and home-school collaboration: Focusing on using information systems for

managing children's growth portfolios, activity records, or home-school communication, with technology primarily serving process optimization and information transmission. (3) Early exploratory research: While recent studies have begun examining AI's potential in areas like child behavior recognition and personalized learning path recommendations, most remain concentrated on learning analytics and assessment rather than curriculum generation itself.

In summary, the vast majority of discussions on technological interventions implicitly assume that "curriculum frameworks already exist", focusing on how to more effectively "implement" or "enrich" the curriculum. However, for technologies like GenAI, which possess powerful content generation and creative inspiration capabilities, there remains a lack of systematic, in-depth exploration into how they can deeply engage in the core process of "curriculum genesis"-transitioning from "early childhood interest phenomena" to "structured curriculum plans". Specifically, there is insufficient research on how GenAI can assist teachers in completing core design tasks such as theme generation, network diagram construction, and activity plan design [32]. Thus, a critical research gap exists: we lack empirical studies examining, from a process-oriented and interactive perspective, how GenAI can be concretely embedded into teachers' curriculum design workflows and how it influences their cognitive processes and decision-making. The interactive essence of kindergarten-based curriculum development calls for a form of technological support that is equally interactive and responsive, pointing toward the supportive interactive relationship described in Lev Vygotsky's "scaffolding" theory.

2.3. The Dilemma of Key Actors: Novice Teachers' "Zone of Proximal Development" and Technology Integration Challenges

In the complex practice of kindergarten-based curriculum development, novice teachers (typically those with 1-3 years of experience) face the greatest challenges. According to the theory of teacher professional development stages, they are situated within the professional ZPD [33], transitioning from theoretical knowledge to skilled practice. Research indicates their core dilemmas in curriculum creation include [34,35]: (1) Difficulty in translating practical knowledge: Despite possessing theoretical foundations, they struggle to flexibly apply these in dynamic educational contexts, resulting in insufficient systematic planning and progressive activity design. (2) Resource scarcity and limited creative capacity: With personal teaching resource libraries still under development, educators often experience creative burnout or over-reliance on ready-made solutions when developing highly context-adaptive and original kindergarten-based curricula. (3) "Reality Shock" and Cognitive Overload: Overwhelming daily responsibilities-including childcare, classroom management, and home-school communication-force educators into "survival mode", leaving minimal time and cognitive capacity for deep curriculum design and reflection. These challenges are not merely individual struggles but pose a direct threat to the "sustainability of teacher professionalism".

Regarding technology integration, the Technology Acceptance Model (TAM) and related research indicate that novice teachers face unique barriers in the adoption process [36,37]: time pressure is the primary obstacle, as learning new technologies requires additional investment; training on GenAI systems tailored for preschool education settings is generally lacking; and their nascent professional confidence makes them more susceptible to technology anxiety, with frustrations in technology use easily diminishing their sense of self-efficacy.

However, existing research on "teacher-technology integration" predominantly follows a linear model of "perceived usefulness-intention to use", focusing on predicting adoption behaviors or evaluating post-use outcome variables (such as teaching effectiveness and job satisfaction). These studies fail to deeply reveal how technology, as an intermediary tool within specific task processes, dynamically influences and shapes

teachers' professional cognition, decision-making logic, and problem-solving processes. In other words, when introducing GenAI to support novice teachers in developing kindergarten-based curriculum, treating it merely as another static tool requiring "adoption" perpetuates these theoretical limitations. Such an approach fails to uncover the micro-mechanisms of "technology-human" collaborative work.

2.4. Convergence of Theoretical Perspectives: Constructing an Analytical Framework for "Digital Scaffold"

Based on the above literature review, three distinct lines of research progress emerge clearly: the educational application potential of GenAI, the generative characteristics of kindergarten-based curriculum development, and the professional development challenges faced by novice teachers. However, research examining these three areas in conjunction remains virtually nonexistent. More critically, existing studies lack a core theoretical perspective capable of integrating the interactive relationship among technology, tasks, and users.

Vygotsky's sociocultural theory, particularly the concepts of the ZPD and scaffolding, provides a robust analytical framework to address this gap [38]. Originally, "scaffolding" referred to temporary, adaptive support provided by more capable individuals to help learners bridge the gap between their current independent problem-solving abilities and their potential developmental level. With the advancement of digital technology, the physical form of "scaffolding" has expanded from human-to-human interaction to human-to-machine interaction [39,40]. This study introduces the core analytical concept of "digital scaffolding", specifically referring to GenAI as a digital tool that provides novice teachers-positioned within their professional ZPD-with temporary, interactive resource support, cognitive inspiration, and strategic guidance while they undertake the complex task of designing kindergarten-based curricula.

Conceptualizing GenAI as a "digital scaffold" demonstrates theoretical appropriateness in two key ways: First, it precisely addresses the essential needs of the research subjects-namely, the competency gap novice teachers face in curriculum creation, which constitutes their ZPD requiring urgent external support. Second, it provides a clear framework for integrating research questions: studies can systematically explore the scaffold's functions (RQ1), interactive mechanisms (RQ2), teachers' critical internalization (RQ3), and its limitations (RQ4). Third, it elevates the theoretical perspective, prompting research to transcend functional evaluations of technology and instead examine how it operates as a sociocultural mediating tool-specifically, how it mediates and shapes teachers' professional practices and cognitive development. This shift moves the discourse from a "technological instrumentalism" to a "technological mediation practice".

In summary, existing literature has separately revealed the potential of GenAI, the characteristics of garden-based curriculum development, and the challenges faced by novice teachers. However, there remains a lack of in-depth exploration at the intersection of these three areas, particularly from the interactive perspective of "digital scaffolding". Therefore, grounded in the overarching concern of "sustainable educational development", this study aims to resolve a core contradiction: How does GenAI, theoretically endowed with dual potential, impact novice teachers situated within their professional ZPD when it intervenes as a "digital scaffold" in the concrete practice of garden-based curriculum development-a process highly dependent on context and generativity? This study argues that addressing this question requires moving beyond generalized discussions of "tool efficacy" to delve into micro-level "technological mediation practices", analyzing how human-machine interactions concretely shape teachers' cognition, decision-making, and professional experiences. Only through such examination can we determine whether GenAI serves as an enabler that enhances teacher resilience and supports sustainable curriculum innovation, or as a "shaky scaffold" that may exacerbate practical challenges and undermine educational sustainability due to

inherent tensions in its contextual and relational dimensions. To explore this tension, this study poses the following four specific questions:

RQ1: At different stages of kindergarten-based curriculum design (e.g., theme generation, network diagram design, activity planning), what specific types of professional challenges do novice teachers primarily use GenAI to address? What specific expectations and needs do they have regarding the functionality of this "digital scaffolding"?

RQ2: How does GenAI specifically function as "scaffolding" in teachers' curriculum design? How does it mediate teachers' thought processes, decision-making, and interactions with curriculum content and imagined young learners?

RQ3: How do novice teachers evaluate the appropriateness and educational value of content generated by GenAI? What critical usage and creative adaptation strategies do they exhibit?

RQ4: What primary opportunities, technical difficulties, practical obstacles, and ethical concerns do novice teachers perceive in using this "digital scaffold"?

3. Materials and Methods

This study adopts a qualitative research design aligned with an interpretivist research paradigm [41], aiming to gain an in-depth understanding of novice preschool teachers' subjective experiences, personalized meaning-making, and the underlying logic of their practical use of GenAI as a digital scaffolding tool within the specific context of school-based curriculum development. The research focuses on the richness, situatedness, and individual variability of the phenomenon itself, rather than seeking universal causal relationships or conducting quantitative verification. Semi-structured in-depth interviews serve as the primary research method to explore how teachers perceive, comprehend, utilize, and critically evaluate GenAI in authentic teaching scenarios. The following sections will detail the participant selection process, data collection procedures, and analytical methods.

3.1. Sample

This study was conducted in accordance with Article 32 of China's "Ethical Review Measures for Life Sciences and Medical Research Involving Humans", which stipulates that ethical review may be exempted for research that uses data obtained through non-interventional methods such as observation. The participants were in-service kindergarten teachers with full capacity to provide consent, and all took part voluntarily. The researchers explained to the participants the purpose of the study, the interview content, the anonymization of data, and their right to withdraw at any time without providing a reason. No sensitive personal information was collected during the research, and the interviews focused solely on routine teaching practices and perspectives, with no anticipated physiological or psychological risks. The entire research process strictly followed the principles of the Declaration of Helsinki regarding respect for participants, beneficence, non-maleficence, and justice.

The study employed a purposive sampling strategy to ensure that the selected participants could provide in-depth information most pertinent to the research's core questions [42]. The specific participant selection criteria were as follows: (1) being a full-time teacher employed in a public or private kindergarten; (2) having a total work experience of no more than four years, aligning with the common definition of a "novice teacher" in educational research; (3) holding a specific role in the design or implementation of the school-based curriculum; and (4) possessing preliminary knowledge or some practical experience with Generative Artificial Intelligence, such as having used tools like Doubao (a GenAI application).

Given the researcher's resources and since no new themes emerged during the interviews, a final sample of ten novice teachers meeting the above criteria participated in

the study. Prior to the interviews, the researcher fully explained the study's purpose, content, and data usage to all participants. Interviews were conducted only after obtaining their informed consent, with a commitment to strict anonymization of all personal information and data. The basic demographic information of the participants is presented in Table 1.

Table 1. Basic Information of Participants (N=10).

Number	Years of Work Experience	Age	Class in Charge	Main Channels of Exposure to GenAI
A1	Four years	21	Small class	Social media
A2	Two years	22	Middle class	Mobile internet
A3	One year	21	Middle class	Teacher training; official accounts
A4	Half a year	23	Large class; Middle class	Graduate studies
A5	One year	23	Large class	Training; official accounts; colleague sharing
A6	Half a year	23	Middle class	Internet
A7	Over one year	24	Small class	Social apps; news reports; conversations with friends
A8	One year	23	Middle class	News; science videos
A9	Two years	24	Large class	Teacher training
A10	Half a year	23	Middle class	Internet

3.2. Research Tools and Data Collection

This study primarily employed a self-designed semi-structured in-depth interview protocol as the data collection tool. The design of the protocol was based on a preliminary literature review and closely centered around the core analytical perspective of "digital scaffolding". It encompassed six main dimensions: (1) participants' basic information (e.g., age, years of work experience, class in charge); (2) basic understanding of GenAI; (3) usage in the curriculum design and development stage; (4) application during the teaching implementation stage; (5) main challenges and concerns encountered during use; and (6) outlook on the future application of GenAI. The interview consisted mainly of open-ended questions, encouraging respondents to share their genuine views based on their personal experiences. Examples include: "Have you had any prior exposure to technologies related to GenAI? Through what channels did you learn about it?" "What potential application scenarios do you think GenAI might have in the field of preschool education?" "What resource-related difficulties do you usually encounter when designing kindergarten-based curriculum? Has GenAI helped you solve any of these problems?" During the interviews, follow-up questions were asked flexibly based on the specific context to delve deeper into the logic behind the viewpoints and the concrete situations.

All interviews were conducted one-on-one by the researcher via online calls, with an average duration of approximately 15 minutes. The entire interview process was audio-recorded with the participants' prior consent. Subsequently, all audio recordings were transcribed verbatim into text. After verification and organization, a raw text corpus of approximately 15,045 words was formed for subsequent analysis.

3.3. Data Analysis: Organization of Interview Materials and Theme Development

The analysis of interview data in this study employed reflexive thematic analysis. This method is not only a systematic process of coding techniques but also emphasizes the ongoing dialogue and meaning-making between the researcher and the text. It aims to distill core themes that reflect participants' shared experiences and underlying perceptions from their rich and specific narratives [43]. To enhance the credibility of the analysis, a protocol coding process was adopted: first, two researchers familiar with qualitative methods independently performed the coding. Subsequently, they compared

their results and negotiated any discrepancies. If disagreements persisted, a third team member was invited to review until consensus was reached, forming a consistent coding system. The entire analysis process was closely centered around the core metaphor of "digital scaffolding" and mainly consisted of six phases.

Phase One: Text Preparation and Initial Reading. After verbatim transcription and verification of all interview recordings, a text corpus of approximately 15,045 words was prepared for analysis. The researcher repeatedly and holistically read all transcripts while listening to the recordings, striving for an in-depth understanding of the overall content and context of the text. During this process, the researcher wrote initial reflective memos, documenting first impressions and thoughts about the text.

Phase Two: Generating Initial Codes. The researcher conducted open coding manually, analyzing the text line by line. The coding process focused on preserving participants' original terms. For example, "and then can also create some teaching aids" was coded as "Generating Teaching Aids"; "these can all bring us inspiration" was coded as "Inspiration Stimulation"; and "can improve the teacher's efficiency" was coded as "Improving Teaching Efficiency".

Phase Three: Constructing Themes. The numerous, fragmented initial codes from the previous phase were repeatedly compared and clustered, subsequently being grouped into more abstract themes capable of summarizing the core content of the text (see Table 2). This process was consistently guided by the "digital scaffolding" framework, investigating how the codes reflected different types, functions, usage patterns, and potential instabilities of scaffolding. For instance, codes like "Instant Generation of Curriculum Resources" "Curriculum Innovation and Inspiration Stimulation" and "Efficiency Accelerator for Work" were clustered to form the theme "Scaffolding as a Resource and Activity Generator". Codes such as "Lack of Trust in Content Reliability" "Technical Operation Barriers" and "Ethical and Privacy Warnings" were clustered to form the theme "Critical Examination of Scaffolding Reliability".

Table 2. Example of Thematic Analysis Coding Table.

Core Theme	Sub-theme	Initial Code	Data Example
Opportunities	Instant Generation of Curriculum Resources	Generating Operational Steps	"GenAI might be able to help with that. For example, you input 'Dragon Boat Festival theme for the middle classes' and it could generate specific operational steps and accompanying short stories."

Phase Four: Reviewing and Refining Themes. The preliminary thematic framework was systematically cross-checked against the entire set of original interview transcripts. This ensured that each theme comprehensively and accurately covered and reflected the data content, while also maintaining clear boundaries between themes, logical interconnections, and no overlap. This process underwent several iterations to form a stable thematic structure.

Phase Five: Defining and Naming Themes. A clear and precise definition was written for each finalized theme, articulating its core essence. The most characteristic phrase encapsulating its nature was then selected for naming. For example, the themes mentioned above were formally designated as "Opportunity: GenAI as a Scaffold for Curriculum Resource Generation" and "Challenge: GenAI as a 'Shaky Scaffold'-Issues of Accuracy, Appropriateness, and Privacy Risks".

Phase Six: Writing the Analysis Report. In the "Findings" section of the paper, these refined themes were used to structure the narrative. By embedding the most representative and vivid excerpts from the original interviews as evidence, the analytical discussion achieves both theoretical depth and generality, while remaining firmly grounded in the authentic experiences and vivid voices of novice teachers.

Through the systematic analysis of the aforementioned six phases, a final framework consisting of 3 core themes and 9 sub-themes (see Table 3), encompassing 50 open codes

and 149 valid interview excerpts, was formed. This framework was used to organize the subsequent discussion in the findings section.

Table 3. Structure of Core Themes and Sub-themes.

Core Theme	Sub-theme
Opportunities	Instant Generation of Curriculum Resources
	Curriculum Innovation and Inspiration Stimulation
	Work Efficiency Accelerator
Challenges	Erosion of Trust in Content Reliability
	Technical Skill Barriers
	Ethical and Privacy Concerns
Teacher Professional Agency	Critical Evaluation
	Creative Adaptation
	Understanding and Defining Human-AI Relationships

4. Results

Based on a reflexive thematic analysis of interview data, this section systematically presents the research findings organized around the core metaphor of the "digital scaffold". First, it depicts the multifaceted opportunities offered by GenAI as a supportive tool, highlighting its value as a scaffold. It further reveals the instability inherent in its application and the challenges faced by teachers, reflecting the shaky or imperfect nature of this support. Finally, it comprehensively presents teachers' professional agency within these interactions. All quotations use participant pseudonyms to protect privacy.

4.1. Opportunities in Application: The "Digital Scaffold" as a Multidimensional Support System

This section addresses RQ1 and RQ2, presenting how teachers specifically utilize GenAI as a tool to support their curriculum design and implementation

4.1.1. Real-Time Resource Provision, Addressing Resource Scarcity

Teachers have come to regard GenAI as a primary tool for addressing instructional resource shortages. Its core value lies in its ability to provide immediate and precise responses to diverse resource needs, fundamentally transforming the traditionally time-consuming, inefficient, and uneven-quality landscape of resource searching. Consequently, it has become the preferred choice for teachers acquiring teaching materials. As kindergarten teacher A1 stated:

"When I search online [...] the images are very blurry [...] So I ask AI to generate them for me."

Another kindergarten teacher, A3, described:

"For example, by entering 'Mid-Autumn Festival theme for middle class', it can generate the steps for activities and short stories, saving me from spending hours searching for materials."

These practices clearly demonstrate that GenAI can respond instantly to teachers' resource needs, positioning it as a preferred tool to tackle resource scarcity. This effectively alleviates the frustration and time pressure experienced by novice teachers due to resource shortages, thereby freeing up their cognitive resources for more creative curriculum planning.

4.1.2. Catalyzing Curriculum Innovation and Expanding Creative Boundaries

GenAI's support for teachers has moved beyond the singular function of "basic resource provision", evolving to deeply participate in instructional design as a "curriculum innovation partner". It provides creative support that transcends the boundaries of individual teacher experience, enabling curriculum design to achieve greater depth, flexibility, and engagement. This role not only enriches course content but

also offers crucial elastic support during key teaching moments, thereby strengthening teachers' professional confidence and the flexibility of curriculum implementation when confronting pedagogical uncertainties. As kindergarten teacher A2 noted:

"Besides using AI to generate activities like flower appreciation, it can also supplement with a timeline chart showing a seed's germination process [...]."

This adds an element of inquiry to the curriculum and enriches the thematic content. When faced with situations like an original plan being obstructed or a child's sudden interest, GenAI can quickly generate adaptable solutions, addressing the passive dilemmas of traditional teaching. Kindergarten teacher A1 mentioned:

"If a child suddenly asks me why it rains [...] I can have AI quickly generate a small activity to teach following the child's interest." This approach both prevents instructional disruption and ensures the curriculum remains responsive to children's needs, enhancing its flexibility.

4.1.3. Enhancing Workflow Efficiency and Streamlining Desk Work

GenAI has become a significant aid for teachers in simplifying tedious desk work and reclaiming instructional time. Its core function lies in automating repetitive, mechanical administrative tasks, thereby liberating teachers from time-consuming clerical duties. This allows them to redirect more energy towards core teaching and teacher-child interactions, a factor recognized as crucial for maintaining teacher efficacy and professional well-being. As kindergarten teacher A8 described:

"I can put the requirements for some topics and the main content I envision into the AI, and have it help me complete an overall lesson plan design."

Another kindergarten teacher, A6, also mentioned:

"It can help us accelerate the pace of curriculum development, for instance, by handling those trivial tasks of collecting materials."

These statements reveal that by taking over the repetitive and time-consuming segments of desk work, GenAI creates more time for teachers to invest in child interaction and the refinement of curriculum depth.

4.2. Challenges in Application: Risks, Obstacles, and Critical Perspectives

This section addresses RQ3 and RQ4, revealing the instability of GenAI as a "scaffold", as well as teachers' critical awareness of and responses to these issues.

4.2.1. A Trust Deficit in Content Reliability

Teachers' concerns regarding GenAI-generated content are concentrated in three areas: accuracy, age-appropriateness, and cultural/contextual relevance. These concerns directly impact teaching quality and child development, constituting the core source of anxiety in their use of GenAI. As kindergarten teacher A1 expressed:

"If AI gives wrong information, like saying rabbits eat meat, the child might remember it [...] It becomes difficult to correct them later."

This fear of "cognitive misguidance" compels teachers to verify the accuracy of content line by line, creating a significant burden. Secondly, content generated by GenAI often leans towards being generic, failing to reflect specific regional cultural characteristics or the practical context of the kindergarten, thus limiting its usefulness. As teacher A9 mentioned:

"What it generates might be too broad; content specifically tailored to a particular region or ethnic direction is scarce, requiring additional research on my part."

These concerns necessitate teachers acting as gatekeepers at every step. This pervasive lack of trust and the consequent verification burden not only offset some of the efficiency gains but also continuously consume teachers' attention and mental energy, potentially eroding the smoothness of their professional work and their sense of psychological safety.

4.2.2. Practical Hurdles in Technical Operation and Content Integration

In the practical operation of GenAI, teachers encounter challenges not as isolated technical issues but as a chain of operational difficulties encompassing "prompt communication, device support, and content integration". This ultimately undermines the convenience GenAI is supposed to offer. For teachers, the primary operational barrier is "using precise prompts to make AI understand pedagogical needs". As kindergarten teacher A1 frankly stated: "The prompt I give it and the output it provides me sometimes seem like they're about two completely different things." Secondly, the limitations of existing hardware in kindergartens further exacerbate the operational difficulty of using GenAI, presenting an unavoidable hard constraint. As teacher A3 explained:

"There aren't enough devices in the kindergarten, and the computers or tablets have average specs. Running AI tools might cause them to lag terribly."

Finally, even when the AI's output aligns with the intended direction, teachers still need to invest considerable time in reworking the content to integrate it into actual lessons. Teacher A6 admitted:

"I need to spend time selecting and adapting it according to the actual situation [...] It hasn't saved me much time."

These three types of operational difficulties compound each other, causing GenAI to transform from a "convenient tool" into "an additional hassle to manage" in teachers' eyes. This is also a significant reason why many teachers are hesitant to adopt it. It is evident that without user-friendly technical design and a supportive environment, the introduction of GenAI may fail to fulfill its promise of empowerment. Instead, it could become a new barrier that heightens teachers' technological frustration, reduces their willingness to integrate technology, and thus impacts the long-term sustainability of technological support.

4.2.3. Ethical and Privacy Red Lines: Defining Clear Boundaries of Use

When using GenAI, teachers maintain a high level of vigilance regarding ethical and privacy risks. This "red alert" serves as the clearest basis for defining the boundaries of its use. Furthermore, vague concerns about the potential ethical problems of over-reliance on AI determine the scope and depth of GenAI's application. As kindergarten teacher A1 stated bluntly:

"I'm afraid that after you send these photos to the AI [...] The internet is too vast, you can't be sure where those photos might end up."

Simultaneously, teachers harbor implicit concerns about the potential ethical issues of excessive reliance on AI. The core of education lies in emotional connection and face-to-face interaction, while the mechanical interaction of AI cannot replace a teacher's gaze, language, and emotional feedback. As teacher A7 worried:

"Over-reliance on AI for interaction might reduce those genuine exchanges between children and teachers."

The hard red line of children's data privacy and the soft constraint of over-reliance on AI together constitute teachers' "red alert" regarding the ethics and privacy of GenAI. This vigilance itself is a manifestation of teachers upholding the fundamental principle of sustainability: safeguarding the humanistic core of education and children's well-being. It also suggests that any technological application ignoring these red lines is unlikely to gain enduring professional acceptance.

4.3. Teacher Professional Agency: Evaluation, Adaptation, and Role Reconfirmation

This section comprehensively addresses RQ3 and RQ4, demonstrating that teachers are not passive recipients but active evaluators and adaptors.

4.3.1. The Critical Gatekeeper: Quality Appraisal and Screening of GenAI Generated Content

Throughout the entire process of integrating GenAI content into teaching practice, teachers assume the role of a "gatekeeper". Drawing from practical experience, they have developed a set of informal yet crucial evaluative criteria centered on safety, developmental appropriateness, and feasibility. This framework is used to critically screen GenAI-generated content, ensuring teaching quality and child development safety. As kindergarten teacher A3 outlined the operational process:

"The first step is to check if it's suitable, the second step is to see if it has educational value, and the third step is to assess if it's safe."

Another teacher, A9, emphasized the core position of developmental appropriateness:

"I consider whether it aligns with the developmental characteristics of the children's age [...] whether it will genuinely promote their physical and mental development."

This informal but vital evaluation framework, born from practice, serves as the core filtering mechanism through which teachers transform external technological output into safe and appropriate educational practice. It highlights their non-negotiable professional responsibility and judgment authority within human-AI collaboration.

4.3.2. From Tool User to Collaborative Creator: Localized Adaptation of GenAI Output

Confronted with the raw output of GenAI, teachers' roles have shifted from passive "users" to active "collaborators". Through targeted localized modification, they adapt AI content to deeply fit the specific teaching context of their class and the developmental needs of their children. As teacher A4 stated:

"If what is generated isn't quite suitable, then I don't adopt it; I make changes myself." Teacher A3 also mentioned:

"AI provides a simple story framework first, and then I revise it according to the children's ideas, saving me from having to start from scratch."

This creative adaptation leverages GenAI to save time in lesson preparation while, through teachers' professional modifications, preserves the relevance and personalization of teaching. This demonstrates the core agency of teachers in the application of intelligent technology, allowing GenAI to truly become a "collaborative partner" in pedagogical innovation. The cycle of "generation-evaluation-adaptation" transcends simple tool use, showcasing a professional model of critical co-creation. In this process, teachers are not passive recipients but active contextual architects, ensuring the curriculum is ultimately rooted in the local educational ecology.

4.3.3. Defining the Core of Human-AI Relations: Clarifying the Boundary between Assistive Tool and Teacher Agency

Through their interactive practice with GenAI, teachers have formed a clear, ultimate positioning of "human-AI relations", reaching a high degree of collective consensus: GenAI is a powerful tool, a capable assistant, and a collaborative partner in teaching, but it can never replace the teacher. As teacher A3 noted:

"It could be a great helper for school-based curriculum development [...] But the core is still that AI assists the teacher; it cannot substitute for the teacher."

Teacher A10 also mentioned: "It is just an assistive tool, helping us integrate resources quickly." While GenAI can provide standardized content frameworks and save time on tedious preparation, it cannot truly discern the unique needs of each child, nor can it flexibly adapt to specific teaching scenarios. Ultimately, it is always the teacher who anchors the direction of the curriculum and designs instruction tailored to the children's reality. As teacher A5 emphasized:

"In the end, it is definitely the teacher who designs the curriculum based on real-life situations and the children's interests."

The collective consensus among teachers regarding their role as the "final designer" is a clear response to anxieties about "technological substitution" and a reconfirmation of the core value of teachers in the intelligent age. It establishes that, in educational practice, human professional judgment, emotional connection, and ethical care constitute the sustainable foundation that technology cannot replicate.

5. Discussion

This study conceptualizes GenAI as a "digital scaffold" based on Vygotsky's sociocultural theory, delving into how it intervenes in the highly contextualized professional practice of novice preschool teachers developing kindergarten-based curricula. The findings not only reveal specific manifestations of human-machine collaboration within a particular educational stage but also deepen our understanding of technology-enabled teaching, teacher knowledge development, and professional identity reconstruction through dialogue and tension with existing theories and literature.

5.1. The Duality of the "Digital Scaffold": Empowering Potential and Structural Fragility

Addressing the challenges faced by novice teachers (RQ1) and the potential risks of the tool (RQ4) central to this study, we found that GenAI as a "digital scaffold" exhibits a distinct duality. Existing research on GenAI's educational application generally affirms its potential as a powerful "content production tool" and "creativity-inspiring partner", capable of effectively enhancing teacher efficiency and creativity [44,45]. This study, within the specific context of preschool education, confirms this fundamental empowering aspect. It further precisely positions GenAI as an immediate support system for novice teachers confronting three core challenges: "resource scarcity" "inspiration depletion" and "cognitive overload". This finding concretizes the generalized discourse of "efficiency enhancement" into targeted replenishment for the professional ZPD of novice kindergarten teachers. It allows the "scaffold" metaphor to materialize in practice, helping to alleviate their initial occupational stress and creating cognitive and emotional space for the stabilization and growth of their professional identity.

However, the key contribution of this study lies in its systematic revelation of the inherent "structural fragility" of this "digital scaffold" within the preschool education context, a fragility rooted in the contradiction between its technological logic and educational philosophy. This significantly extends beyond existing literature, which often focuses on general risks like technological "hallucination" or academic integrity [24,46]. We found that the core of its fragility lies in a profound tension with the fundamental principles of preschool education. First, the tension with "contextualized curriculum creation". The essence of kindergarten-based curriculum is "local-based and for the local" [26], deriving its vitality from deep embeddedness in specific communities, kindergarten culture, and the dynamics of the child group. GenAI's "decontextualized" generative logic, trained on massive generic datasets, often renders its outputs perceived as "vague templates" or "soulless skeletons". This echoes critics' observations regarding AI's incapacity to understand and generate "local knowledge" [47], which is drastically amplified in the highly tacit-knowledge-dependent practice of curriculum development. Second, the tension with the "relational nature of teaching". High-quality preschool education is founded on sensitive teacher-child interactions and relationship building [48]. The profound concern expressed by teachers-the worry that over-reliance on AI might blunt their own observational acuity and responsiveness-is not unfounded. This directly points to the risk of "de-skilling" potentially introduced by technological mediation, where teachers could be reduced from creative curriculum "co-constructors" to mere "implementers" of pre-set plans [49]. The deeper contradiction lies in the mismatch between GenAI's "decontextualized" generative logic and the "deeply contextualized" practice required in preschool education. This firstly threatens the sustainability of curriculum quality, as templates lacking cultural soul cannot support long-term, vibrant

curriculum evolution. Secondly, it triggers anxiety regarding the sustainability of teachers' professional competency, potentially eroding their long-term professional capital for handling complex situations [50-52].

5.2. Beyond Tool Adoption: The Complex Evolution of Novice Teachers' TPACK and Agentic Practice

The classic Technological Pedagogical and Content Knowledge (TPACK) framework describes the integrated knowledge form resulting from the complex interplay between Technological Knowledge (TK), Content Knowledge (CK), and Pedagogical Knowledge (PK) [53]. Much related research implicitly follows a linear development assumption of "foundation first, integration later", positing that teachers need a solid base of CK and PK before they can effectively integrate TK. The findings of this study challenge this mainstream assumption.

We found that when using GenAI, novice teachers exhibited a TPACK development path characterized by "reverse generation" or "nonlinear leap": they frequently and strategically used GenAI (as advanced TK) as a "shortcut" to directly access ready-made "Pedagogical Content Knowledge" (PCK)-such as a complete thematic web or activity lesson plan. This phenomenon aligns with the trend observed by Rosenberg and Koehler [54] of teachers employing AI as a "pedagogical shortcut", revealing a potentially more efficient and adaptive initial model for professional learning enabled by intelligent technologies. For overburdened novice teachers, accessing prototypes of PCK directly through GenAI may be regarded as a fast track into communities of practice.

The theoretical significance lies in a dialectical twofold revelation: On one hand, this indeed harbors the risk of "knowledge hollowing out". If teachers stop at uncritically applying templates, their own CK and PK may stagnate due to the lack of a construction process.

On the other hand, and more constructively, when teachers' professional agency is activated, this "shortcut" can be transformed into a "catalyst for deep learning". To evaluate, adapt, and localize an AI-generated PCK plan, teachers are compelled to engage in profound reflection. This process essentially constitutes "reflective practice mediated by technology", where TK is no longer the endpoint of integration but becomes the starting point and leverage for actively reconstructing CK and PK. This expands the theoretical boundaries of TPACK, suggesting that in the intelligent age, teacher knowledge development may be a more iterative, interactive, and co-constructive process mediated by technology.

Thus, the process of GenAI mediating teachers' curriculum design (RQ2) is not merely a simple tool application. Instead, it is a process that stimulates teachers' critical evaluation and creative adaptation (RQ3) and, in reverse, propels the complex evolution of their TPACK knowledge structure. This indicates that in the age of artificial intelligence, teacher professional development may be a cyclical process of continuous dialogue and iterative co-construction with technological tools, rather than a linear accumulation of knowledge. This offers new insights for designing sustainable professional development systems that support teacher lifelong learning.

5.3. Reconfirmation of Professional Identity: From Labor-Substitution Anxiety to the Return of Core Value

Regarding the impact of automation technology on professional work, there exists a widespread societal anxiety about "labor substitution" [55]. Confronting these common ethical concerns about technological replacement (RQ4), the teachers in this study provided a clear answer through their professional practice. All participating teachers firmly positioned GenAI as a "tool" and an "assistant". This consensus in itself is a manifestation of professional agency.

More importantly, the study found that as AI assumed part of the "cognitive labor" involved in information retrieval, drafting text, and generating creative ideas, the core of teachers' professional work did not shrink. Instead, it underwent a distinct process of "value concentration" and "role ascension". This aligns closely with scholarly perspectives emphasizing(Shulman, 1987; see also Selwyn) [49,56] the irreplaceability of teachers' complex decision-making and humanistic care and is concretized and contextualized in this research: Firstly, in an era of information overload and difficulty discerning truth, teachers' professional authority increasingly lies in their judgment, screening, and decision-making abilities based on child development science, educational ethics, and specific cultural values. They guard the "safety gate" and "value red lines" of educational content-a moral responsibility no algorithm can bear.

Secondly, teacher expertise shifts from "designing universal solutions" to "transforming generic resources into effective practice within specific contexts". This transformation relies on a deep understanding and creative synthesis of individual child differences, classroom dynamics, and community resources. It is a highly contextualized "practical wisdom", far beyond the reach of pattern-matching technology. Furthermore, education is ultimately an ethical endeavor of "human encounter" [57,58].AI can simulate dialogue but cannot provide genuine empathy; it can design cooperative games but cannot create a psychological atmosphere filled with trust and support. This study reinforces the teacher's eternal and unshakable core role as an emotional supporter, relationship builder, and personality influencer. Thus, in the face of technological permeation, teachers' irreplaceability lies not in repetitive labor but in their core role of safeguarding the humanistic, contextual, and ethical nature of education. They are the immune system ensuring that educational technology application does not deviate from the essence of educating people. They are the transformational hub connecting global digital resources with localized educational practice. They are the stable cornerstone maintaining the emotional warmth and trusting relationships within the learning environment. Investing in and strengthening these core competencies of teachers is the most important strategy for building a sustainable educational ecosystem capable of adapting to technological change while preserving its humanistic core.

6. Conclusions

6.1. Research Summary

This study conceptualizes GenAI as a "digital scaffold" and explores how it intervenes in novice preschool teachers' kindergarten-based curriculum design practices. Through in-depth interviews and analysis with 10 teachers, the research reveals a complex and tension-filled picture of the technological integration process, leading to the following core conclusions:

The study, based on interviews with novice teachers, finds that GenAI plays a dual role in kindergarten-based curriculum development. It functions both as an empowering tool capable of providing resources, inspiring creativity, and enhancing efficiency, and as a "scaffold" that is inherently fragile due to concerns over content reliability, technical barriers, and tensions with core preschool education values such as contextuality, child-centeredness, and safety. Teachers' profound concerns regarding its accuracy, appropriateness, and privacy security essentially reflect inherent contradictions between the technological tool and the sustainability of educational quality and child well-being.

Simultaneously, novice teachers demonstrated strong professional agency. They are not passive recipients of technology but actively assume the roles of "gatekeepers" and "collaborators". Through the practice of "generation-evaluation-modification", they engage in critical scrutiny and localized adaptation of AI outputs. This process is not merely a tool-use strategy but constitutes a sustainable learning pathway for the iterative development of professional knowledge (TPACK) mediated by technology.

More importantly, the intervention of AI prompts a shift in the emphasis of teacher professional identity. The irreplaceability of teachers ascends from foundational information processing and design labor to higher-order competencies such as contextualized judgment, ethical decision-making, and emotional connection. These capacities are precisely the cornerstone for building a resilient educational ecosystem and safeguarding the sustainable development of education's humanistic core. Therefore, teachers in the intelligent age are not subjects to be replaced but are key actors guiding technology for good and upholding the fundamental values of education.

6.2. Research Limitations and Future Directions

This study has certain limitations. Firstly, the sample consists of novice teachers from a specific cultural context in China, whose experiences are shaped by local educational policies and technological environments. The cross-cultural generalizability of the conclusions requires further testing. Secondly, the reliance on self-reported interview data suggests that future research could incorporate multimodal data such as classroom observations and artifact analysis to more comprehensively capture the micro-interactions of human-AI collaboration. Finally, as a cross-sectional design, this study could not track the long-term evolution of teachers' interaction capabilities with AI or its sustained impact on career development.

Based on the above findings and limitations, future research could deepen exploration in the following directions: First, conducting longitudinal studies to track the long-term impact of GenAI on teacher burnout, retention intentions, and professional identity, which directly concerns the sustainability of the teaching workforce. Second, undertaking cross-cultural comparative studies to investigate whether patterns of human-AI collaboration and their contribution to sustainable educational goals differ across educational systems and cultural values. Third, promoting participatory design research, collaborating with teachers and technology developers to co-create AI tool prototypes that better support "contextualized creation" and "critical collaboration". Fourth, expanding the research scope to the dimension of educational equity, examining disparities in the application of GenAI across kindergartens with varying resource conditions, and its potential impact on SDG 4.

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Abbreviations: The following abbreviations are used in this manuscript

GenAI	Generative Artificial Intelligence
SDG 4	Sustainable Development Goal 4
LLMs	Large Language Models
ZPD	Zone of Proximal Development
TAM	Technology Acceptance Model
TPACK	Technological Pedagogical and Content Knowledge

TK	Technological Knowledge
CK	Content Knowledge
PK	Pedagogical Knowledge
PCK	Pedagogical Content Knowledge

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