

Article

How Specific Design Features in E-Picture Books Support Preschoolers' Emergent Reading: A Mixed-Methods Study

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Abstract

This mixed-methods study examines how specific design features (SDF) in e-picture books influence phonological awareness (PA) and print knowledge (PK) among Chinese preschoolers. Ninety 5-year-old children were assigned to three groups: an e-picture-book group, a paper-book group, and a regular-preschool-program control group. All participants completed pretests of PA and PK, followed by a four-week reading intervention and post-tests. The quantitative results showed that the e-picture-book group significantly outperformed the control group in terms of PA, whereas no statistically significant differences were found between the e-picture book and paper-book groups or across groups regarding PK. Qualitative analyses of observations and semi-structured interviews further revealed two key mechanisms through which design features, such as pronunciation support, playback functions, and interactive hotspots facilitated children's sensitivity to sound structures. In contrast, features intended to support PK (e.g., highlighted print) showed limited effectiveness, partly due to insufficient salience and the visual complexity of Chinese characters. These findings suggest that e-picture books may support phonological development in Chinese preschoolers, particularly through auditory and interactive design features, although no significant advantage was observed compared to narrated paper-book reading. However, their impact on print knowledge appears to depend on the alignment between design features and the characteristics of the Chinese writing system. This study highlights the importance of optimizing print-referencing features and incorporating instructional support to enhance early literacy outcomes.

Keywords: electronic picture books; emergent reading; specific design features; e-book design; mixed methods

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1. Introduction

Emergent reading is a critical stage in early childhood during which foundational literacy skills develop, including the ability to understand print concepts, phonological awareness, and word recognition (Lomax & McGee, 1987). In the Chinese context, phonological awareness (PA) and print knowledge (PK) are widely recognized as core components of emergent reading (Altun, 2018; Chow et al., 2005; Huang & Hanley, 1995). Although reading is emphasized in preschool education, formal instruction in Chinese characters is typically not introduced at this stage (H. Li & Rao, 2000), and existing practices are often hindered by challenges such as limited resources, low engagement, and insufficient interaction.

With the increasing integration of digital technologies into early education, children's reading experiences are shifting toward electronic picture books (e-picture books), which incorporate multimodal elements such as audio narration, animation, and interactivity (Liman Kaban & Karadeniz, 2021). Compared with traditional print books, these multimodal features may better support children's engagement and emergent literacy development by providing auditory, visual, and interactive scaffolding (Bus et al., 2015; Korat & Segal-Drori, 2016).

However, most previous studies have focused on comparisons between print and digital formats, with limited attention to how specific design features (SDFs) within e-picture books contribute to different dimensions of emergent reading (Halamish & Elbaz, 2020; Korat & Segal-Drori, 2016). This limitation is particularly evident in studies involving non-alphabetic languages such as Chinese, where literacy development follows distinct pathways. In addition, studies on Chinese preschoolers typically rely on single-book interventions and rarely examine children's learning processes through observational or qualitative approaches (An, 2018; Niu et al., 2015; Yue, 2014). As a result, the mechanisms through which SDFs influence different dimensions of emergent reading remain insufficiently understood.

To address these gaps, this study investigates how SDFs in e-picture books support emergent reading among Chinese 5-year-old preschoolers, with a particular focus on their roles in facilitating phonological awareness and print knowledge development, as well as the underlying mechanisms of multimodal learning.

1.1. Emergent Reading Among Chinese 5-Year-Old Preschoolers

Research has consistently shown that phonological awareness and print knowledge are foundational to later reading success across languages (Whitehurst & Lonigan, 1998; Kim, 2016), yet the nature of these skills varies with writing systems. Alphabetic literacy emphasizes phonemic awareness, letter recognition, and print concepts. In contrast, Chinese literacy draws on syllable awareness, tone sensitivity, radical knowledge, and visual-orthographic skills, reflecting the tonal and logographic properties of Chinese characters (Shu et al., 2008; C. Li et al., 2021).

1.1.1. Phonological Awareness of 5-Year-Old Chinese Preschoolers

Phonological awareness (PA) refers to children's sensitivity to and ability to manipulate the sound structures of spoken language, including syllables, rhymes, onsets, rimes, and tones (Anthony & Lonigan, 2004). Unlike alphabetic languages that emphasize phoneme-level awareness, Chinese phonological development relies more heavily on syllable, onset-rime, and tone awareness because changes in tones alter lexical meaning in Mandarin (Pan et al., 2016; Shu et al., 2008).

Research suggests that Chinese children's PA develops progressively between the ages of 3 and 6. Syllable awareness generally emerges first, followed by onset-rime and tone awareness, which require more refined phonological processing (Shu et al., 2008; Tang & Wu, 2009). Around age 5, children demonstrate increasing sensitivity to syllable segmentation, rhyme detection, and sound manipulation, all of which are associated with early Chinese-character recognition (Chan et al., 2008; Fang, 2016).

Shared reading and technology-enhanced activities have been shown to support PA development. A recent meta-analysis of 19 technology-based phonological awareness interventions confirmed that there were consistent positive effects for preschoolers (Raposo-Rivas et al., 2024). Specifically, repetitive and rhyming texts help children recognize sound patterns, while activities such as syllable clapping and sound-matching promote segmentation and blending skills (Grofčíková & Máčajová, 2017). Furthermore, read-aloud interventions that explicitly highlight sounds and encourage children's verbal responses

positively influence PA outcomes (Noble et al., 2019; Parpucu & Ezmeci, 2024). In China, the 3–6 Years Children Early Learning and Development Guideline (Ministry of Education, 2012) also encourages repeated listening, recitation, and engagement with rhythmic texts, practices that align with PA research (Fang, 2016; Wu et al., 2022).

1.1.2. Print Knowledge of 5-Year-Old Chinese Preschoolers

Print knowledge refers to children's understanding of the forms, functions, and organizational properties of written language and is considered an important precursor to later reading development (Lenhart et al., 2021; Puranik & Lonigan, 2012). In alphabetic languages, print knowledge commonly includes letter recognition and understanding of print conventions, such as left-to-right orientation. In Chinese, however, print knowledge places greater emphasis on visual-orthographic processing because Chinese characters are logographic and visually complex (Liu et al., 2014).

Chinese preschoolers gradually develop sensitivity to character structure, positional regularity, and radical awareness through exposure to environmental print and shared reading experiences (C. Li et al., 2021; Wang et al., 2017). Radical awareness refers to the ability to recognize recurring components within Chinese characters that often provide semantic or phonetic information. Accordingly, Chinese print knowledge commonly involves three interrelated skills: distinguishing real characters from pseudo-characters, recognizing characters, and identifying radicals or structural components (H. J. Chen, 2021).

Developmental studies indicate that children aged 3 to 6 progressively learn to distinguish Chinese characters from pictures, symbols, and pseudo-characters, with substantial gains around ages 4 and 5 (C. Li et al., 2021; Qian et al., 2015). By age 5, many show increasing sensitivity to character composition rules, stroke patterns, and radical positions, although more advanced orthographic awareness continues to develop through primary school (Deng, 2017; Pan et al., 2016). Shared reading supports print knowledge by directing children's attention to print through verbal prompts, finger-pointing, or highlighted text, increasing visual attention and awareness of written language (Justice & Ezell, 2002; Evans & Saint-Aubin, 2013). Similar findings have been reported for Chinese preschoolers (An, 2018; F. Chen & Yang, 2024). Together, these results indicate that explicit attention to print during shared reading effectively fosters early orthographic knowledge in Chinese children.

1.2. Theoretical Framework

Emergent literacy theory proposes that children's reading development begins long before formal schooling through continuous interactions with language-rich environments (Steinman et al., 2006). Developmental models of reading consistently emphasize that early literacy acquisition is gradual and cumulative, with foundational skills that are acquired during the preschool years supporting later reading achievement (Chall, 1996; Fitzgerald & Shanahan, 2000). From this developmental perspective, phonological awareness and print knowledge are widely recognized as key components of emergent reading, and they are particularly important during the transition from prereading to conventional reading.

Complementing this developmental perspective, multimodal theory explains how meaning is constructed through the interaction of multiple representational modes, including visual, auditory, textual, and interactive elements (Kress & van Leeuwen, 2001). In the context of e-picture books, multimodal theory highlights how design features, such as highlighted print, animations, background music, replay buttons, and hotspots may support children's engagement and literacy learning by integrating multiple sensory channels during reading activities.

Drawing on these two theoretical perspectives, this study conceptualizes emergent reading as the developmental outcome and multimodal design features as instructional supports that facilitate literacy learning processes. Specifically, reading development theory identifies phonological awareness and print knowledge as the core dimensions of emergent reading examined in this study, whereas multimodal theory explains how the specific design features of e-picture books may scaffold the development of these skills through multimodal meaning-making processes.

In addition, this framework emphasizes that children's reading behaviors are observable learning processes through which multimodal features may influence literacy development. Behaviors such as repeated listening, interacting with hotspots, attending to highlighted print, and replaying narration may reflect children's active engagement with multimodal resources and support connections between spoken and written language.

As illustrated in Figure 1, reading development theory provides the developmental foundation for emergent reading outcomes, while multimodal theory explains how the specific design features of e-picture books support children's reading behaviors and facilitate the development of phonological awareness and print knowledge.

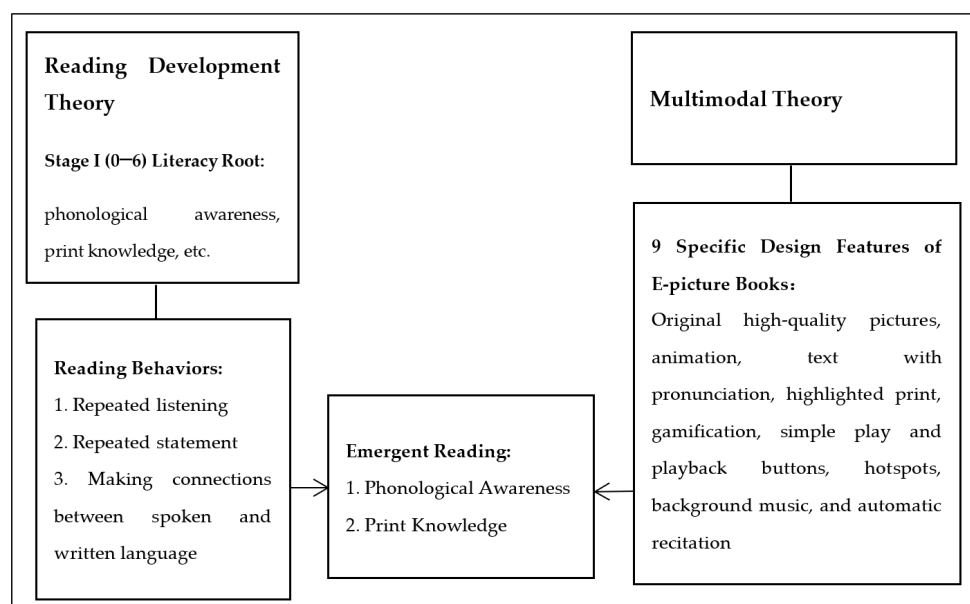


Figure 1. Theoretical framework based on reading development theory (Chall, 1996; Fitzgerald & Shanahan, 2000) and multimodal theory (Barthes, 1977; Kress & van Leeuwen, 2001).

1.3. Research Questions

While the use of e-books as an intervention for emergent literacy development in preschoolers has gained recognition, existing research has yet to fully explore their potential in supporting phonological awareness (PA) and print knowledge (PK) specifically among Chinese preschoolers. More importantly, little systematic attention has been paid to how the specific design features of e-picture books, such as narration, animation, highlighting, and interactive elements, contribute to distinct aspects of emergent reading. In particular, the mechanisms through which these features facilitate young children's cognitive and linguistic development remain underexplored, especially in non-Western educational contexts such as China.

To address these gaps, we adopt a mixed-methods approach grounded in emergent literacy theory and multimodal learning theory. The aim is not only to compare learning outcomes across different reading formats but also to examine how multimodal design features shape children's reading processes and skill development.

This study is guided by the following research questions:

- (1) Is there a statistically significant difference in Chinese 5-year-old preschoolers' phonological awareness (PA) and print knowledge (PK) across three conditions: (a) e-picture book reading, (b) paper-book reading with a narrator, and (c) a regular preschool programs without an additional reading intervention?
- (2) How do the specific design features of e-picture books support Chinese 5-year-old preschoolers' PA and PK? What roles do these features play in facilitating different dimensions of emergent reading, such as phonological segmentation, rhyming, character recognition, and orthographic awareness?

By addressing these questions, we aim to contribute a more nuanced understanding of digital-reading design in early childhood education. The findings are expected to inform the development of effective e-picture books tailored to the linguistic and cognitive characteristics of young Chinese learners.

2. Materials and Methods

2.1. Participants

Participants were recruited from T Kindergarten, a suburban public kindergarten in Chongqing, China. A total of 90 preschoolers were selected based on the following inclusion criteria: the participants had to be (a) 5 years old; (b) native Chinese speakers proficient in Mandarin; and (c) willing to participate in reading assessments and picture-book reading sessions. The final sample consisted of 90 children (43 boys, 47 girls), with ages ranging from 56 to 74 months ($M = 65.2$ months, $SD = 3.8$).

2.2. Research Design

We employed a parallel mixed-methods design in which quantitative and qualitative data were collected concurrently. For Research Question 1, a quasi-experimental design was adopted. Prior to the intervention, all participants completed pretests assessing phonological awareness (PA) and print knowledge (PK). Based on their pretest scores, the children were ranked and assigned to three groups using a matched-group procedure to ensure comparable baseline literacy levels across conditions: (a) an e-picture-book group, (b) a paper-book group, and (c) a control group.

The intervention was conducted over four weeks and consisted of four reading sessions, with one session per week. Each session lasted approximately 20 min and took place during regular classroom activities in the participating preschool. The two experimental groups read the same two picture books in the same sequence, with each book read twice across two consecutive sessions. The children in the e-picture-book group read electronic versions of the books, whereas the children in the paper-book group read printed versions accompanied by pre-recorded narration. Teachers were present during the sessions to maintain classroom routines and provide procedural assistance, when necessary, but they did not provide additional literacy instruction. The control group continued participating in the regular preschool curriculum without any additional reading intervention. Following the intervention, all participants completed a post-test identical to the pretest.

For the quantitative analysis, a planned comparison between the e-picture-book group and the regular preschool-program control group was specified a priori because it directly addressed the primary objective of determining whether e-picture-book reading provided benefits beyond regular preschool activities. This comparison was theoretically motivated by previous research suggesting that e-picture books may facilitate phonological awareness through multimodal features such as audio narration, pronunciation support, and interactive elements (Bus et al., 2015; Korat & Segal-Drori, 2016; Takacs et al.,

2015). Because this comparison was specified a priori to test the primary research hypothesis, no adjustment for multiple comparisons was applied.

For Research Question 2, a qualitative component was embedded within the e-picture-book condition. Purposive sampling was used to select six children representing different levels of engagement for in-depth analysis. Data were collected through observations and semi-structured interviews.

2.3. Reading Materials

The picture books used in this study were the Chinese versions of *A Taste of the Moon* and *The Rainbow Flower*. These two books were selected because they are comparable in terms of narrative structure, linguistic difficulty, story length, and suitability for 5-year-old preschoolers. Both stories feature relatively simple sentence structures, repetitive language patterns, and clear narrative sequences that support young children's engagement and comprehension.

Both books were presented in print and electronic formats. The electronic versions were accessed through the Yila Reading application, a widely used digital reading platform in China. These e-picture books retained the original illustrations while incorporating multimodal features such as highlighted print, animations, hotspots, and interactive elements. To ensure consistency across conditions, the same stories and narration content were used in both the e-picture- and paper-book groups.

A detailed page-by-page analysis identified a total of 460 specific design features across both e-picture books (including 323 in "*A Taste of the Moon*" and 137 in "*The Rainbow Flower*"). These SDFs formed the basis for the subsequent qualitative analysis examining how multimodal design features supported preschoolers' phonological awareness and print knowledge development.

2.4. Research Instruments

Children's Phonological Awareness Test Task (CPATT): The Children's Phonological Awareness Test Task (CPATT), adapted from J. Li (2003), was used to assess children's phonological awareness. The instrument comprises four subtests: (a) Syllable Awareness, in which children manipulate syllables within words; (b) Onset Awareness, in which children identify the odd syllable based on the initial sound unit; (c) Rime Awareness, in which children identify the odd syllable based on the final sound unit; and (d) Tone Awareness, in which children identify the syllable with a different tonal contour among three options. A previous study reported satisfactory reliability for the instrument, with reliability coefficients ranging from 0.81 to 0.82 (J. J. Li, 2010).

Children's Print Knowledge Test Task (CPKTT): The Children's Print Knowledge Test Task (CPKTT), adapted from Deng (2017), was used to assess children's print knowledge. The instrument consists of three subtests: (a) Character Distinction, which requires children to distinguish real Chinese characters from non-characters; (b) Character Recognition, which assesses recognition of six frequently occurring characters appearing in the books used in the intervention; and (c) Character Structure Awareness, which requires children to identify the common radical shared by a group of Chinese characters. Previous research has reported good internal consistency for this instrument ($\alpha = 0.804$).

Observation List for 5-year-old Preschoolers' Electronic-Picture-Book-Reading Behavior: A specialized observation tool was developed to examine how 5-year-old children interact with electronic picture books in the Chinese context. The checklist summarized ten key behaviors potentially supporting emergent reading during e-picture-book engagement: repeated clicking to listen (RL), repeated statement (RS), initiating a question (IQ), describing content (DC), focused listening (FL), establishing one-to-one correspondence between words and pictures (MC), predicting (P), role-playing (RP), laughing (L),

and imitating (I). To ensure reliable analysis, the researcher and a colleague specializing in preschool education independently observed and recorded children's behaviors. Discrepancies were resolved through discussion and video review. Inter-rater reliability, measured using Cohen's kappa, was 0.840, indicating substantial to near-perfect agreement.

Semi-Structured Interview Protocol: An interview protocol was developed to gather insights into factors affecting the development of emergent reading through electronic picture books. The protocol consisted of 19 questions designed to understand children's responses to various design features (e.g., recognition, audio–visual feedback, confusion, and expectations). To ensure clarity, the protocol was reviewed by three experts in preschool education and the Chinese language. Prompts were included to facilitate children's expression.

2.5. Ethical Considerations

Prior to data collection, ethical approval was obtained from the Human Research Ethics Committee of Universiti Sains Malaysia (Ethics Approval Code: USM/JEPeM/PP/23080611). Permission to conduct the study was also obtained from the principal of T Kindergarten. Because the participants were all under 7 years of age, informed consent was sought from the parents of all children before the study commenced. The purpose and objectives of the study were clearly communicated to families and teachers, and all parents gave their written informed consent for their children's participation. Additionally, the researcher used simple language and visual aids to explain the study's purpose and procedures to the preschoolers. Verbal assent was also obtained from each child before participation.

3. Results

Before the effects of the intervention were examined, baseline equivalence across the three groups was assessed using pre-test scores for PA and PK. As shown in Table 1, the three groups demonstrated comparable pre-test performance across both measures, indicating that the matched-group assignment procedure was effective in establishing similar baseline literacy levels prior to the intervention.

Table 1. Pre-test descriptive statistics for phonological awareness (PA) and print knowledge (PK) across the three groups.

Measure	Group	<i>n</i>	Mean	Std. Deviation
PA	E-Picture Book	30	14.40	6.25
	Paper Book	30	15.17	6.15
	Preschool Program	30	14.93	5.91
PK	E-Picture Book	30	8.07	3.49
	Paper Book	30	7.00	2.90
	Preschool Program	30	7.17	3.27

3.1. RQ1: Differences in Emergent Reading Across Three Conditions

Following confirmation of baseline equivalence, post-test scores were analyzed to examine the effects of the three reading conditions on preschoolers' phonological awareness (PA) and print knowledge (PK).

3.1.1. Results Related to the PA Test

Table 2 presents the results of the normality tests for the PA post-test scores across the three groups. All Shapiro–Wilk test values were non-significant ($p > 0.05$), indicating that the assumption of normality was satisfied.

Table 2. Normality tests for phonological awareness (PA) post-test scores of the three groups.

Group	Kolmogorov–Smirnov			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
E-picture book	0.105	30	0.200 *	0.951	30	0.185
Paper book	0.119	30	0.200 *	0.971	30	0.562
Preschool program	0.091	30	0.200 *	0.975	30	0.671

* This is a lower bound of the true significance.

Descriptive statistics for the PA post-test are presented in Table 3. The e-picture-book group achieved the highest mean score ($M = 19.83$, $SD = 4.58$), followed by the paper-book group ($M = 18.40$, $SD = 4.87$) and the preschool program group ($M = 16.97$, $SD = 4.94$).

Table 3. Post-test descriptive statistics for phonological awareness (PA) across the three groups.

Group	<i>n</i>	Mean	Std. Deviation	Std. Error Mean
E-Picture Book	30	19.83	4.579	0.836
Paper Book	30	18.40	4.868	0.889
Preschool Program	30	16.97	4.937	0.901

A one-way ANOVA was conducted to compare PA post-test scores across the three groups. The results indicated that the overall group effect was not statistically significant: $F(2, 87) = 2.84$, $p = 0.064$, and $\eta^2 = 0.061$ (Table 4).

Table 4. One-way ANOVA for phonological awareness (PA) post-test scores across the three groups.

Source	Sum of Squares	<i>df</i>	Mean Square	<i>F</i>	<i>p</i>	η^2
Between Groups	129.089	2	64.544	2.835	0.064	0.061
Within Groups	1980.867	87	22.769			
Total	2109.956	89				

Planned comparisons were conducted to examine specific differences among the intervention conditions. The results showed that the e-picture-book group scored significantly higher than the preschool program group, $F(1, 58) = 5.79$, $p = 0.019$. No significant differences were found between the e-picture- and paper-book groups or between the paper-book and preschool program groups.

3.1.2. Results Related to the PK Test

Table 5 presents the descriptive statistics for PK post-test scores across the three groups. The e-picture-book group achieved the highest mean score ($M = 9.93$, $SD = 4.31$), followed by the preschool program group ($M = 9.60$, $SD = 3.72$) and the paper-book group ($M = 8.77$, $SD = 4.04$). However, the median scores tell a slightly different story: the preschool program group had the highest median ($Md = 9.50$), while both the e-picture-book and paper-book groups had medians of 8.00.

Table 5. Post-test descriptive statistics for print knowledge (PK) across the three groups.

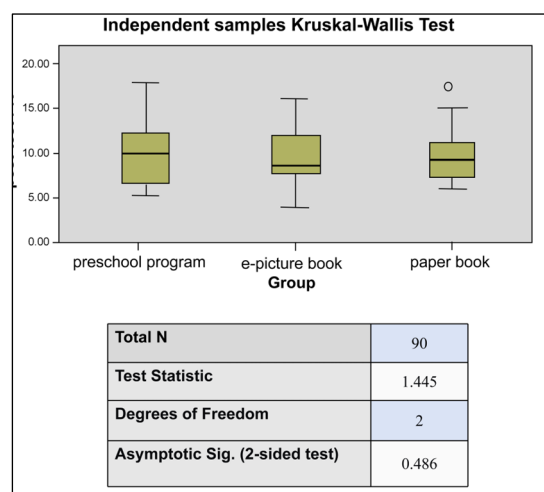
Group	<i>n</i>	Mean	SD	Median
E-Picture Book	30	9.93	4.31	8.00
Paper Book	30	8.77	4.04	8.00
Preschool Program	30	9.60	3.72	9.50

Normality testing (see Table 6) revealed that the PK post-test scores were not normally distributed. The Shapiro–Wilk test yielded *p*-values of 0.044 for the preschool program group, 0.004 for the e-picture-book group, and 0.002 for the paper-book group, all falling below the 0.05 threshold. Accordingly, a non-parametric test was used for group comparisons.

Table 6. Normality tests for the print knowledge (PK) post-test scores across the three groups.

Group	Kolmogorov–Smirnov			Shapiro–Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Preschool program	0.139	30	0.144	0.928	30	0.044
E-picture book	0.223	30	0.001	0.886	30	0.004
Paper book	0.195	30	0.005	0.878	30	0.002

A Kruskal–Wallis test was conducted to compare PK scores across the three groups. The results showed no statistically significant differences: $H = 1.445$ and $p = 0.486$. As illustrated in Figure 2, the distribution of PK post-test scores was similar across all three conditions.

**Figure 2.** Boxplot of print knowledge (PK) post-test scores across the three groups.

Taken together, these results indicate that while the e-picture-book group had the highest mean PK score, the differences among the three groups were not statistically significant. In other words, neither e-picture-book nor paper-book reading with a narrator produced a measurable advantage over the regular preschool programs in terms of print knowledge among 5-year-old Chinese preschoolers.

3.2. RQ1: How Do the Specific Design Features of E-Picture Books Support PA and PK?

To address research question 2, we analyzed observational data collected during the four-week intervention period and semi-structured interview data gathered from six preschoolers in the e-picture-book group after the intervention.

For data organization and retrieval during qualitative analysis, each observation record was assigned a unique identification code indicating the participant, the e-picture book read, and the observation session: “C” (child), “E” (e-picture book), and “T” (time). Table 7 describes this labeling scheme.

Table 7. Observation -data identification scheme.

Type	Code Format	Description
Child	C + number (1–6)	Six children selected from the e-picture-book group
E-picture book	E + number (1–2)	Two e-picture books used during the intervention
Observation session	T + number (1–4)	Four reading sessions conducted over four weeks

After all observation records and interview transcripts were organized, thematic analysis was conducted according to Braun and Clarke’s (2006) six-phase approach. Data were first reviewed repeatedly and then coded using a combination of deductive and inductive strategies. Initial codes were derived from both the observation protocol and relevant literature on e-picture books and emergent reading, while additional codes emerged from the data. Similar codes were grouped into categories and synthesized into broader themes.

To enhance trustworthiness, the coding process involved iterative refinement and expert validation (Braun & Clarke, 2006). Redundant or ambiguous codes were revised, merged, or removed through constant comparison across data sources. Two experts in early childhood education and qualitative research independently reviewed the coding scheme, data extracts, and category definitions using a structured validation form with a five-point agreement scale. Discrepancies (e.g., distinguishing “questioning” from “predicting”) were resolved through discussion and refinement of operational definitions. Triangulation across observation and interview data further strengthened credibility.

Table 8 presents an overview of the thematic analysis framework, including the themes, categories, and representative codes that emerged from the data. The following sections present the findings for phonological awareness (PA) and print knowledge (PK) separately.

Table 8. Development of themes from observation and interview data.

Research Question	Theme	Category	Representative codes
PA	Through strengthening auditory information	Enhanced listening	Repeated listening, listening closely
	Through promoting phonetic practice	Manipulating pronunciation	Splitting sounds, distinguishing sounds
		Repeatedly practicing pronunciation	Saying something again, repetition with variation
PK	Through stimulating repetitive practice	Strengthening oral expression	Questioning, describing, predicting
		Repeated exposure to text	Repeated listening, saying something again
	Through effective auditory–visual integration	Integration of language modalities	Connecting spoken and written language, guessing from shape

3.2.1. How Do the SDFs Support Chinese 5-Year-Old Preschoolers’ PA?

Our observations revealed that five SDFs—simple play and playback buttons, automatic recitation, text with pronunciation, highlighted print, and hotspots—elicited behaviors supportive of PA development. Table 9 presents the types and frequencies of these behaviors across the two e-picture books.

Table 9. Frequency of phonological awareness (PA)-supportive behaviors across two e-picture books.

Behavior	Quantity for E-Picture Book 1	Quantity for E-Picture Book 2
Repeated clicking to listen	75	49
Describing the content	14	7
Predicting the storyline	5	0
Saying something again	5	5
Initiating a question	2	2

The semi-structured interview protocol consisted of nine questions designed to explore how the five SDFs supported PA in preschoolers. In accordance with the methodology outlined by Miles et al. (2014), the data were analyzed through coding and categorization. Observation and interview data were merged for triangulation and then organized and coded according to the five SDF types. Data segments with similar meanings were assigned the same code.

These codes were then grouped into four categories, from which two overarching themes emerged.

Theme 1: Auditory Learning

Auditory learning refers to the ways in which SDFs, particularly simple play and playback buttons, automatic recitation, text with pronunciation, highlighted print, and hotspots, help preschoolers acquire PA-related knowledge and skills through repeated, focused listening and sound manipulation (e.g., identifying syllables, onsets, rhymes, and tones). This theme comprises two categories.

Category 1. Enhanced Listening

Features such as simple play and playback buttons, text with pronunciation, highlighted print, and hotspots encouraged preschoolers to repeatedly click the screen to listen to specific sentences and pronunciations. As shown in Table 9, “repeated clicking to listen” was the most frequent behavior observed (with 124 occurrences across both books). Hotspots and text-with-pronunciation features elicited repeated-listening behavior among all six children, with hotspots generating the highest number of clicks. The simple play and playback buttons triggered this behavior in only two children (C1 and C6). An example is provided below:

The e-picture book automatically flipped to ant rowing. She clicked on the small river twice and then the playback button but quickly switched to the next page. (C6E2T3)

Other children (C1 and C2) expressed similar enjoyment in clicking hotspots to hear sounds or using playback buttons to listen to sentences again. In contrast, the automatic recitation feature, while providing a consistent model of correct pronunciation, did not elicit repetitive listening behavior during the observation period. Nevertheless, most children (C1, C2, C4, C5, and C6) stated in the interviews that they enjoyed the narration and found the volume appropriate.

Category 2. Manipulating Pronunciation

Features such as highlighted print and hotspots helped the preschoolers manipulate pronunciation, particularly in tasks involving splitting and distinguishing sounds. For instance, Child 5 made the following note during an interview:

“I can recognize these words. I will connect three words and click on them.”

By isolating and emphasizing each character, he could break words into smaller syllables, improving his ability to manipulate sounds in rhyming or blending tasks. Similarly, Child 2 responded to another interview question by saying:

“I like it. Because I want to hear what he is saying.”

This interaction helped him distinguish between different sounds, thereby supporting his phonological awareness.

Theme 2: Phonetic Practice

This theme highlights how features such as automatic recitation, text with pronunciation, highlighted print, and hotspots in e-picture books encourage preschoolers to practice pronunciation and engage in oral language behaviors. These interactions help them focus on and manipulate the words and sentences within the story. This theme is divided into two categories.

Category 3. Repeatedly Practicing Pronunciation

The “text with pronunciation” and “highlighted print” features prompted the preschoolers to repeat words during reading. Examples from the observation records are given below:

She repeatedly clicked on the title of the book and then said aloud, “A Taste of the Moon.” (C1E1T1)

After listening to the sentence, he repeated, “They still can’t get the moon.” (C5E1T1)

As Child 1 and Child 5 repeated the title and phrases, their pronunciation and fluency improved. This repetitive practice helped them enhance their pronunciation, solidify their understanding of word sound structures, and ultimately enhance their PA.

Category 4. Strengthening Oral Expression

The observations showed that the preschoolers’ oral expression frequently involved questioning, describing, and predicting. These activities helped them improve pronunciation, including recognizing syllables, onsets, rhymes, and tones in Chinese characters, thereby enhancing their phonetic skills.

The automatic recitation feature allowed the preschoolers to see pictures and words while hearing their pronunciation. Child 1 and Child 2 described images while listening to the automatic reading of e-picture book 2:

She said happily, “The rainbow-colored flower is not dead.” (C1E2T3)

He listened and said, “It’s snowing.” (C2E2T3)

By narrating what they saw or heard, the children practiced using language to express their thoughts, reinforcing both phonetic and vocabulary skills. In addition, hotspots were the most engaging feature with respect to encouraging preschoolers to speak. This interactive element kept all six children engaged and allowed Child 1, Child 2, and Child 3 to predict sounds and words based on context, reinforcing phonetic practice through repetition and prediction. A sample observation is given below:

He repeatedly clicks on the little fish to make it swim and talk. The child looks up and says, “The moon is fake.” (C2E1T1)

Overall, the preschoolers enjoyed the click-and-turn functionality in the e-picture books, which provided them with more opportunities to speak and practice oral expression.

3.2.2. How Do the SDFs Support Chinese 5-Year-Old Preschoolers’ PK?

The observations revealed that two SDFs—text with pronunciation and highlighted print—were particularly effective in enhancing preschoolers’ print knowledge by causing them to engage with the text in meaningful ways. These features encouraged behaviors that support PK, such as saying something again and repeated clicking to listen. Table 10 reports the frequency of these behaviors across the two e-picture books.

Table 10. Frequency of PK-supportive behaviors across two e-picture books.

Behavior	Quantity for E-Picture	Quantity for E-Picture Book
	Book 1	2
Repeated clicking to listen	31	16
Saying something again	8	5

Based on a comparison of positive reading behaviors, Child 2 and Child 5 were selected as key examples for the use of “text with pronunciation” in supporting PK, while Child 1 and Child 5 were chosen for “highlighted print”. Three interview questions addressed these two SDFs to further examine their role in supporting PK. Data from observations and interviews were triangulated, coded, and categorized, leading to the identification of two key themes.

Theme 3: Repetitive Practice

Repetitive practice with text-with-pronunciation and highlighted print features encouraged the preschoolers to engage with the text repeatedly, e.g., by listening to the same text multiple times or repeating words. This practice strengthened their ability to recognize characters and increased their awareness of character structure.

The observations showed that both SDFs prompted preschoolers to actively interact with the text through behaviors such as repeatedly clicking on text or clicking the screen. Three children (C1, C2, and C6) clicked on highlighted print four times, and all six children clicked on text 27 times to hear how it should be pronounced. C1, C2, and C5 repeated the text six times, and two children (C1 and C5) repeated highlighted print twice. The following is an illustrative observation:

The child wrapped his hand around the tablet, opened the picture book, listened to the book title on the cover, and repeated the book title, “The Rainbow Flower again”.
(C5E2T4)

By repeatedly listening to the pronunciation while seeing the corresponding text, Child 5 better internalized the connection between sounds and symbols. This is especially beneficial for Chinese preschoolers, helping them recognize the unique shapes and sounds of Chinese characters. In an interview, Child 5 confirmed this:

Researcher: Did you read these Chinese characters while listening to this story?

Child 5: I can recognize these words. I will connect three words and click on them.

Researcher: How do you think e-picture books can help you recognize this Chinese character?

Child 5: I can also draw it and have the e-book read it out.

This finding aligns with observational data showing that the children used the tablet to repeatedly click and listen in order to learn how to pronounce unfamiliar characters. However, most of the preschoolers (C2, C3, C4, C5, and C6) clicked quickly without fully listening to the text, sometimes casually touching the screen rather than intentionally engaging with the text.

Theme 4: Auditory–Visual Integration

Auditory–visual integration in e-picture books refers to the combination of auditory (sounds and spoken words) and visual (written text and images) information to help preschoolers better understand the meanings of Chinese characters. This integration is crucial for developing PK, as it helps children connect the sounds they hear with the words they see, thereby enhancing character recognition.

This theme emerged from the interview responses. Some children (C1, C5, and C6) indicated that they could combine pronunciation with the text in the e-picture books. For instance, Child 1 stated the following:

Yes, I can find these words. When I click them, they can produce pronunciations.

This shows that Child 1 was able to easily follow along with the text while listening to the pronunciation, supporting both auditory and visual learning.

In contrast, other preschoolers (Children 2, 3, and 4) sometimes relied on the accompanying pictures to infer the meaning of unfamiliar words. Note the example below:

Researcher: How do you think e-picture books can help you recognize this Chinese character?

Child 2: Guess, look at the shape and guess.

Child 3: Look at the painting there, there is an elephant there, and there is an elephant next to this character.

Child 4: You can look at the pictures next to these words. Guess from the picture.

While these children made use of visual cues to infer word meanings, such guesses were often approximate, and the children did not always consciously attempt to memorize the characters.

Highlighted print also played an important role in integrating auditory and visual information. When a character was highlighted, it drew the child's attention, making it easier to focus on specific information. For example, Child 1 noted the following:

Yes, I can find these words (the highlighted print). When I click them, they can produce pronunciations.

In this case, the highlighted print served as a bridge between the visual representation of a character and its corresponding sound, helping Child 1 actively engage with the text and associate the characters with their correct pronunciations.

4. Discussion

4.1. Implications

This mixed-methods experimental study investigated the effects of e-picture books on emergent reading skills among Chinese 5-year-old preschoolers, with a particular focus on phonological awareness (PA) and print knowledge (PK). The findings revealed that children in the e-picture book group showed higher PA performance than the preschool program group, whereas no statistically significant differences were observed for PK. These findings suggest that e-picture books may support certain aspects of emergent literacy, particularly phonological awareness, but their effects should be interpreted cautiously given the comparable outcomes observed between the two reading intervention conditions. The results further indicate that the effectiveness of e-picture books may depend on how their design features align with the specific cognitive and linguistic demands of Chinese literacy development.

Consistent with prior research (e.g., Chera & Wood, 2003; Flack et al., 2018; Korat & Segal-Drori, 2016), the children in the e-picture-book group demonstrated significantly higher PA than those in the preschool program group. However, the absence of a statistically significant difference between the e-picture-book and paper-book groups suggests that the benefits observed may not be unique to digital reading environments, as they may also reflect the contribution of repeated story exposure and narrated reading experiences more generally. Notably, the strongest effect pertained to tone awareness, which is in line with Hua and Dodd's (2000) model of Chinese phonological development, which posits that tones are acquired earlier than finals and consonants. The qualitative findings further elucidate two key mechanisms underlying this effect: auditory learning and phonetic practice. Features such as playback buttons, automatic recitation, text with pronunciation, highlighted print, and interactive hotspots provided repeated access to accurate pronunciations, thereby increasing the children's sensitivity to sound structures. This pattern is

consistent with previous studies (Grimshaw et al., 2007; Zucker et al., 2009), which highlight the role of repeated auditory input in promoting phonological processing. Moreover, children who more frequently engaged with pronunciation-related features (e.g., hotspots) tended to show greater improvements in rhyme and phoneme awareness, supporting the argument that interactive engagement enhances phonological development (Raposo-Rivas et al., 2024).

In contrast, the absence of significant group differences in regard to PK diverges from earlier findings suggesting that e-books can support early print-related skills (Korat & Segal-Drori, 2016; Rvachew et al., 2017; Takacs et al., 2015). Several factors may account for this discrepancy. Although the overall PK pretest scores were moderate, the children demonstrated relatively strong performance in the character distinction subtest prior to the intervention, suggesting a possible ceiling tendency for this component, thereby limiting observable gains. Second, the observational and interview data suggest that the children tended to focus more on illustrations than on textual elements during independent reading, a tendency commonly reported among preliterate children (Evans & Saint-Aubin, 2013). Third, and importantly, the e-picture books used in this study lacked dynamic text highlighting. Unlike Yue (2014), who demonstrated that animated highlighting can enhance print awareness, the relatively static and infrequent highlighting in the materials used in this study may have been insufficient to direct sustained visual attention to Chinese characters. This limitation may be particularly consequential given the visual complexity of Chinese orthography, which requires attention to radicals and stroke configurations rather than linear letter sequences.

Despite the lack of statistically significant effects, the qualitative findings indicate some potential benefits for PK development. Two themes, repetitive practice and auditory–visual integration, emerged from the data. The children who engaged with “text with pronunciation” and highlighted print features showed increased interest in print and occasionally attempted to align spoken language with written characters. Although only two children were able to accurately recognize highlighted text by the end of the intervention, the data suggest that these features may enhance attention to print and increase exposure time. This finding aligns with the work of Dijken (2023), who reported that print-referencing features can support early literacy development even when immediate gains in explicit recognition are limited.

At the same time, most children were unable to reliably identify highlighted words, and some reported that they had not noticed the highlighting at all. This finding suggests that the effectiveness of print-referencing features depends not only on their presence but also on their perceptual salience and developmental appropriateness. In the context of Chinese characters, which are visually dense and complex, textual elements may compete with illustrations and animations for children’s attention. In addition, the relatively low frequency of highlighting in the e-picture books may have reduced its instructional impact. Consistent with the work of Arslan-Ari and Ari (2022), the preschoolers in this study appeared to prioritize visual narratives over textual information during independent reading. Future designs may therefore benefit from more salient visual cues (e.g., larger fonts, color contrast, and animation) or embedded prompts that explicitly encourage attention to print.

4.2. Limitations

Several limitations should be acknowledged when interpreting the findings of this study. First, the intervention consisted of only four 20 min reading sessions conducted over four weeks. Although significant improvements in phonological awareness were observed, the relatively short duration and limited number of sessions may have restricted

the extent to which broader changes in emergent literacy development, particularly print knowledge, could be detected.

Second, the study involved 90 preschoolers from a single public kindergarten in Chongqing, China. Although the sample was appropriate for the mixed-methods design, the findings may not be fully generalizable to children from different geographical regions, socioeconomic backgrounds, or educational settings.

Third, the study focused on independent e-picture book reading. Adult support, peer interaction, and home literacy environments were not systematically examined, although these contextual factors may influence children's engagement with e-picture books and their literacy development. In addition, individual differences such as motivation, attention, and prior exposure to digital reading may have contributed to variations in learning outcomes.

Taken together, these limitations point to several directions for future research. Studies involving more diverse geographical and socioeconomic contexts, including both urban and rural settings, are needed to assess the generalizability of the present findings. Longer-term longitudinal research would help determine whether early gains in PA contribute to later reading outcomes and whether PK improvements emerge over time. Furthermore, future studies adopting a sociocultural perspective could investigate how adult mediation, peer interaction, and home literacy environments shape children's engagement with phonological and print-related features, thereby providing a more ecologically valid understanding of e-picture book use.

5. Conclusions

This study suggests that e-picture books may support phonological awareness development in Chinese 5-year-old preschoolers, particularly through design features that support auditory learning and phonetic practice, such as automatic recitation and pronunciation-related interactivity. However, because no significant differences were found between the e-picture- and paper-book conditions, the findings do not suggest that e-picture books are necessarily superior to narrated paper books in terms of promoting emergent literacy. Rather, the results indicate that both forms of shared reading intervention may provide benefits beyond regular preschool activities.

No statistically significant effects were observed regarding print knowledge. This may be attributable to ceiling effects, the complexity of Chinese orthography, and the limited salience and frequency of print-referencing features in the e-picture books used.

The qualitative findings nonetheless suggest that features such as repetitive practice and auditory–visual integration may help increase attention to print and emerging character recognition. These results indicate that while e-picture books represent a promising tool for supporting emergent literacy in Chinese contexts, their effectiveness depends on the alignment between design features and the specific demands of the writing system.

From a practical perspective, e-picture book design should incorporate more salient and frequent print-referencing features to better support character learning. In addition, adult guidance may play a crucial role in directing children's attention to textual elements, as independent interaction alone does not appear sufficient to promote print knowledge development.

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Abbreviations

The following abbreviations are used in this manuscript:

SDF	specific design feature
PA	phonological awareness
PK	print knowledge

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