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Relationship between natural environment theme picture book design and children's cognitive development: a systematic review

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ABSTRACT

As a primary educational tool for early cognitive and emotional development, picture books are essential for children to learn about and understand the world. Natural environment theme picture books allow children to connect with nature, fostering environmental awareness and conservation values. These books' visual appeal and integrated design directly influence children's interest and engagement, underscoring the importance of well-considered picture book design. This study systematically reviewed 32 articles from 2000 to 2022, including Chinese literature, to analyse research trends and gaps in the relationship between picture book design and cognitive development. This study found that most of the recent research is based on the concept of mental development and the cognitive theory of picture books and often supports the research together with theories or concepts of education, design, and environment and mainly adopts the methods of case study, content analysis, and observation. Most of the research focuses on the combined design elements of the picture book, especially the images and the text-image relationship. However, significant gaps remain in exploring the interdisciplinary and multi-method approaches needed to fully understand the impact of picture book design on cognitive development.

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1. Introduction

1.1. Background

1.1.1. Natural environment theme picture books

Since the birth of picture books, they have been widely used in children's education, especially pre-schoolers, as an essential part of children's literature (Aygün & Abacı, 2014; Lynch-Brown & Tomlinson, 2008). A necessary characteristic of children's literature is that it is adapted to children's cognitive and linguistic abilities at different stages of development (Kümmerling-Meibauer & Meibauer, 2013). Picture books, because of their image and textual interdependence (Moya-Guijarro, 2011; Nodelman, 1988), make a significant educational tool for promoting children's cognitive development (Lewis, 2001) and an essential part of the literacy education process in Western countries (Wu, 2018).

In recent years, the urgency of addressing environmental issues, such as climate change, biodiversity loss, and pollution, has intensified the need for early environmental education. Environmental education for children is increasingly recognised as a vital pathway for shaping sustainable awareness and behaviours in future generations (Chen, 2022; Muthukrishnan, 2019; Wang & Ji, 2022). Nature-themed picture books provide young readers with a convenient and engaging means of connecting with environmental themes, nurturing empathy for nature and fostering a sense of responsibility toward the Earth from a young age (Qi, 2021; Williams et al., 2012). By integrating environmental elements, picture books contribute not only to literacy and cognitive growth but also to the development of ecological awareness, which is essential for fostering pro-sustainable behaviours (Gonen & Guler, 2011; Kümmerling-Meibauer & Meibauer, 2013; Williams et al., 2012).

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Currently, researchers in different countries classify picture books differently. Picture books are typically categorised based on their educational function, and in China, they are increasingly evaluated for cultural relevance and market competitiveness (Lynch-Brown & Tomlinson, 2008; Sun, 2019; Wu, 2018). Globally, mainstream classifications of picture books include narrative picture books, concept books introducing basic concepts like numbers and colours, and informational or non-fiction picture books that provide factual content (Kümmerling-Meibauer & Meibauer, 2013; Nikolajeva & Scott, 2013). Recently, nature, environmental, ecological, and conservation theme picture books have become more prominent across categories, addressing pressing issues like climate change, conservation, and sustainability (Beeck, 2017; Gonen & Guler, 2011; Williams et al., 2012).

Although the works about nature, environment, and ecology are differently addressed, their purpose is similar, which is to let children get to know the ever-changing natural environment and cultivate the consciousness of getting close to nature, cherishing nature, and protecting nature (Ahi et al., 2014; Williams et al., 2012). Wang and Ji (2022) point out that natural environment picture books are an essential part of science picture books, and their primary role is to help children know and understand the knowledge of the natural environment, enhance the connection between children and nature, and play the role of environmental education. In other words, natural environment-themed picture books are publications that embody the themes of nature, ecology, and life, have a clear ecological awareness, convey to children the concept of respecting, adapting to, and protecting nature, and play an essential role in children's cognition of nature and in improving their idea of environmental protection (Gonen & Guler, 2011; Muthukrishnan, 2019; Wang & Ji, 2022). Through interacting with these books, children form basic cognitive frameworks around concepts like nature and ecosystems, understanding how natural systems function and recognise the importance of environmental protection (Beeck, 2017; Williams et al., 2012).

1.1.2. Design of picture books

Current research has generally focused on the functional, literary component of picture books, as this is a foundational attribute of picture books as a branch of children's literature and is inextricably linked to children's cognitive development, particularly language development and independent learning (Kümmerling-Meibauer & Meibauer, 2013; Murray, 2014). In picture books, functionality refers to their role as educational or developmental tools, promoting literacy, language acquisition, and cognitive skills such as problem-solving and logical reasoning (Muthukrishnan, 2019; Nikolajeva & Scott, 2013). Literary elements form the foundational attributes of picture books as works of children's literature, encompassing narrative structure, themes, and textual content that shape emotional and cognitive development (Nikolajeva & Scott, 2013; Qi, 2021). However, the relationship between picture book design and mental development has received limited attention (Beeck, 2017). Design in picture books focuses on visual, structural, and aesthetic components that interact with text to create a multi-sensory experience, influencing how children process content (Huang, 2018; Matulka, 2008; Yang, 2015). For example, studies show that when text and visuals are combined in a complementary way, forming dual coding, children are more likely to understand and retain information (Kümmerling-Meibauer & Meibauer, 2013; Lewis, 2001).

In recent years, however, as the audience's requirements for children's books continue to rise, more and more publishing organisations and creators have begun to focus on the design of picture books to enhance the artistic and aesthetic value of picture books, and thus improve the market competitiveness and influence of their products (Shen & Yang, 2012; Sun, 2019). At the same time, with the development of picture book research, people's interest in the direction of picture book design is growing, and there is a certain amount of research results.

In recent years, researchers have generally agreed that the design of a picture book should be a holistic design framework with comprehensive considerations (Luo & Liu, 2022; Song, 2016), Key design elements include layout, typography, text-image relationships, colour schemes, and physical structure (Huang, 2018; Matulka, 2008; Yang, 2015). Its design elements should not be independent but should coordinate with each other to form a cohesive book (Huang, 2018). Children's picture books should create reading pleasure and guide children to think creatively (Gönen et al., 2012).

Among these, illustration is widely acknowledged as critical; researchers have given various reasons for this, for example, Brookshire et al. (2002) concluded from their study that design elements such as

illustrations have a direct impact on children's choice of books and comprehension of stories and that these design elements create an appeal that can effectively stimulate children's senses and satisfy their needs (Ma et al., 2014). Attractive depictions of fields, forests, and animals in picture books provide children with entertainment and practical information about these places and individuals. In turn, this leads to children's appreciation of nature and the development of young conservationists, developing their long-term connection to the outdoors (Beeck, 2017). However, other design elements also play a significant role in cognitive development. This is discussed further in the subsequent sections.

Therefore, paying attention to the relationship between picture book design and children's cognitive development and developing a design model suitable for children, especially preschoolers, according to their level of mental development and psychological characteristics, should be an essential way to improve the quality of natural environment-themed picture books, fulfil their proper educational role, and meet children's developmental needs (Fang, 2018; Qi, 2021).

1.2. The present study

In previous reviews, there has not been a systematic literature review examining the relationship between picture book design styles and children's cognitive development, nor a study specifically focused on natural environment theme picture books. Currently, researchers have conducted reviews on topics such as picture book reading (Dowdall et al., 2020), picture book teaching (Zhang et al., 2023), and education (Oberman, 2023), with a particular emphasis on shared reading and educational functions of picture books. However, this study has noted that these reviews have varying degrees of attention to the importance of pictures, design, visuals, and other elements in picture books for children's cognitive development (Bai et al., 2022). They also generally acknowledge the value of this research direction in future studies.

In recent years, literature reviews have focused on studying picture books themselves (Wu, 2018). However, this review primarily employs bibliometric analysis methods and mainly focuses on research trends and clusters, with only briefly mentioning aspects such as pictures, design, or visuals. Furthermore, as the most comprehensive and authoritative academic database in China, there are very few literature reviews on this research topic in CNKI (China National Knowledge Infrastructure). Wang and Lu (2017) conducted a literature review on the development, conceptual characteristics, and value of picture books in China. Most of the other researchers only reviewed specific elements of picture book design, such as colour and images in picture book design (Wang & Li, 2022), or reviewed research on the application of picture books in early childhood art education (Ren, 2015).

This review aims to provide a systematic literature review of the relationship between the design styles of picture books, especially those with the natural environment theme, and children's cognitive development. The objective is to clarify how picture book design styles relate to and influence children's cognitive development while defining specific classifications and boundaries of picture book design styles. Additionally, the review aims to identify the primary theoretical support in current research, which is necessary for further defining the theoretical framework of the field. This study also examines recent research's limitations and challenges, identifies gaps, and provides clear research recommendations for future studies.

This study will fill the gap in systematic literature reviews, evaluate current research, support researchers, and highlight research opportunities. It will also benefit Chinese publishers and creators of natural environment-themed picture books.

2. Method

The present review adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as the retrieval method (Moher et al., 2009). This guideline is the foundation for systematic reviews in social sciences. It helps researchers complete systematic literature review reports effectively by clarifying the research question, defining screening criteria, and conducting appropriate database searches (Sierra-Correa & Cantera Kintz, 2015). Following the guidelines, the researcher pre-determined the

protocol's research question, search strategy, screening criteria, and analysis methods. This section will explain the techniques and procedures, along with figures and tables to present the process and results.

The authors selected Scopus, Science Direct, and ERIC as the retrieval databases for this review. This study also consulted Google Scholar and SAGE Journals to ensure the comprehensiveness of the data. Additionally, since this study involves research from China, the search results from CNKI, the most authoritative Chinese literature database, were included, they play a key role in the evolution of natural environment-themed picture book design. The retrieval process and results from CNKI are also presented through figures and tables. The PRISMA flow diagram shows the total journal data above (Figure 1).

2.1. Search strategy

The first stage of this systematic review was to determine the search strategy, which primarily involved identifying keywords and their combinations, search terms were selected concerning the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). First, the search keywords were chosen, which

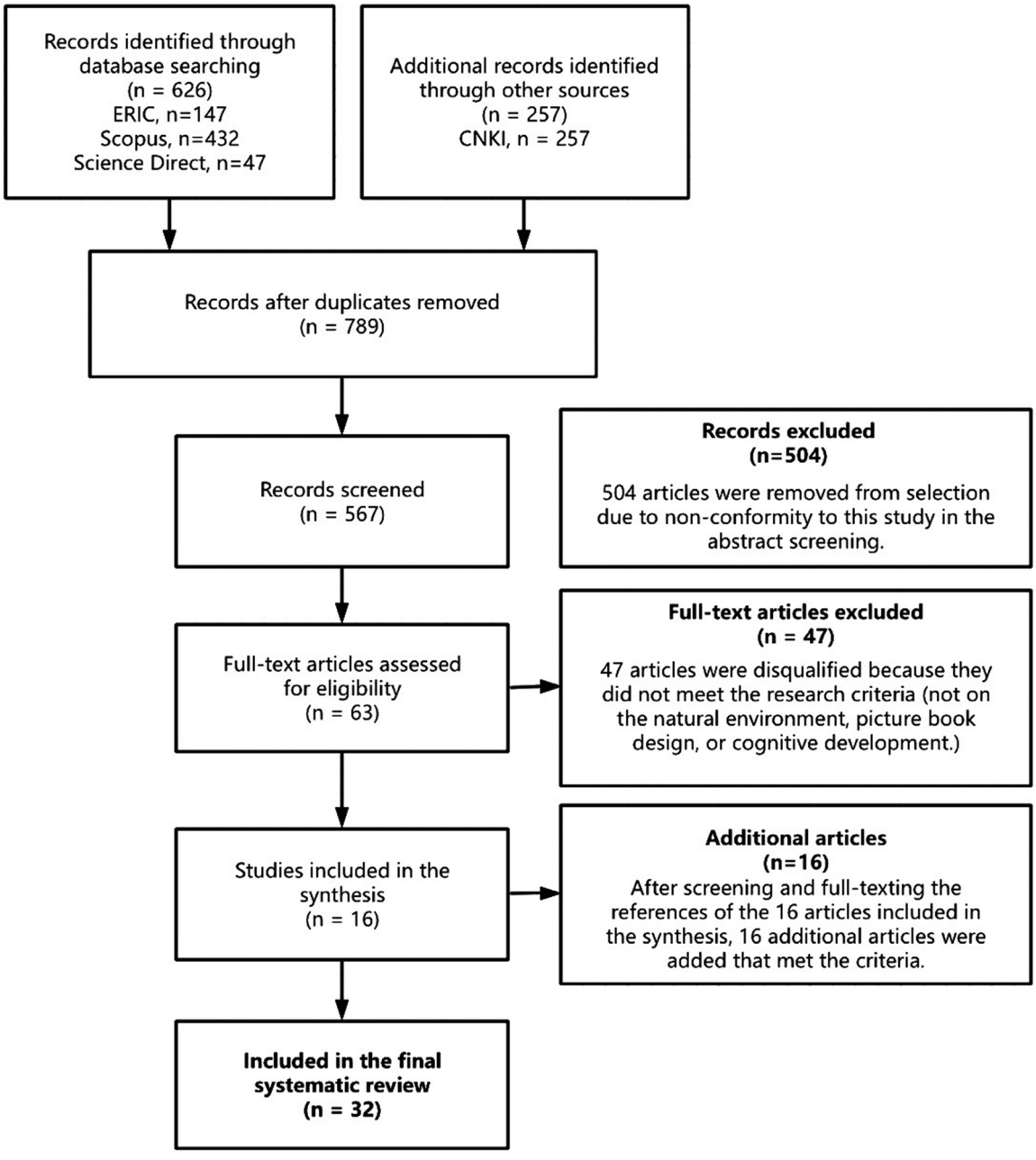

Figure 1. PRISMA flow diagram.

were developed by reviewing previous research in related fields and referring to important literature on children's cognitive development, picture book design and environmental education (Muthukrishnan, 2019; Qi, 2021). The researchers defined keywords and synonyms based on previous studies, dictionaries, and other resources to avoid missing relevant literature due to terminological differences.

This process produces a list of search terms for the three main concepts: Nature environment, picture book design, and cognitive development. The search terms for nature environment included nature environment, natural, environment, and ecology. The search terms for picture book design included picture book design, book design, and illustration. The search terms for cognitive development included children and mental development. These search terms were designed to cover the significant relevant literature as comprehensively as possible. Before finalising these search terms, this study combined the words from the three lists to create search syntax, which was then tested in different databases to assess the suitability of the search results. The authors made the adjustments, and optimisations were made accordingly. It should be noted that these search terms may only encompass some relevant literature. Still, they were derived through repeated testing and adjustments by this study to ensure the accuracy of the search results.

Next, this study combined the search terms using Boolean operators and performed searches in databases such as Scopus, Science Direct, and ERIC, targeting titles, abstracts, keywords, and full-text documents (Table 1). Due to slight variations in search settings across databases, minor adjustments were made. For example, the 'picture book' search condition was added to 'Title, abstract, or keywords' in the advanced settings for Science Direct search results. Additionally, during the search process, all years and sources were included. This decision was made because limiting the search by year or source yielded a small number of articles that met the search terms across the three databases, which would not facilitate further screening, data extraction, and analysis.

Furthermore, only peer-reviewed articles were considered to ensure the quality of the retrieved literature. Ultimately, 626 search results were obtained from these three databases. These search results were merged in tools such as Zotero and Excel, duplicate articles were removed, and titles and abstracts were reviewed and screened, resulting in a final selection of 32 articles.

Furthermore, this study searched the CNKI, a Chinese literature database, using the search terms from the list. Through three different keyword combinations, 257 search results were obtained. After applying the same process of removing duplicate articles and further filtering in Excel, 11 articles remained. Most of the excluded articles from this section were unrelated to the focus of this study, as evident from their titles and abstracts, and thus did not warrant a comprehensive review.

In addition, the same search process was conducted in Wiley Online Library and SAGE Journals. However, due to the large number of search results in these two databases (1350 and 1155, respectively) and considering the accuracy and quality of the search results, these results are often either overly broad or not directly related to the specific focus of this study (for example, many articles reference 'environment' or 'cognitive development' without addressing picture book design). The authors thought these data were supplementary references and did not include them in the subsequent screening process.

2.2. Inclusion and exclusion criteria

The second stage involved a comprehensive review and screening of the literature based on the inclusion and exclusion criteria (Table 2). First, although the search results included literature from all years, considering the relevance to current research, publications before 2000 were excluded. In other words, the inclusion criteria restricted the publication dates from 2000 to 2022, spanning 22 years. Second, as

Table 1. Database and keyword.

Database	Keywords
Scopus Science Direct ERIC	("natural environment" OR nature OR environment OR ecology) AND ("picture book design" OR "book design" OR illustration) AND ("cognitive development "OR children)
WOS SAGE Journals	("natural environment" OR nature OR environment OR ecology) AND "picture book" AND (design* OR illustration) AND ("cognitive development "OR children)
CNKI	nature, environment, ecology, picture books, design, children's cognitive development

Table 2. Inclusion and exclusion criteria.

Criterion	Included	Excluded
Timeline	2000-2022	<2000 and >2022
Language	English and Chinese	Non-English and Non-Chinese
Literature type	Research article	Books, Book chapters, Conference papers, Editorials, Short surveys, and Notes.
Theoretical/Conceptual framework	Theoretical/Conceptual framework	Non-Theoretical/Conceptual framework
Research object	Natural environment, Picture book design, Cognitive development	Non-natural environment, Picture book design, Cognitive development

this study focused on original Chinese picture books, Chinese and English literature were included. Third, to ensure the quality of the literature, non-peer-reviewed and unpublished works were excluded.

Additionally, since the initially screened literature primarily consisted of journal articles, non-journal sources were excluded after further review. Furthermore, literature that needed explicit theoretical or conceptual frameworks was also excluded, considering the need to determine the theoretical support in current research for this review. Lastly, and most importantly, given the focus of this study on the design styles of picture books, particularly those related to natural environment themes and their relationship with children's cognitive development, only literature that addressed the topics of natural environment, picture book design, and cognitive development was included.

Following these selection criteria, a review of the 63 articles from the initial screening in the first stage was conducted, resulting in 16 articles that met the inclusion criteria. With this, the retrieval process was completed (Figure 1, PRISMA flow diagram), and a final list of literature was generated. The excluded literature was mainly unrelated to the topics of natural environment, picture book design, and cognitive development or focused primarily on picture books' reading and educational functions, needing more discussion on picture book design.

It should be noted that after completing the above search and screening process, the researchers thoroughly screened the references of 16 articles by snowballing them. After browsing through the titles and abstracts to find 26 papers and further full-text in-depth readings, 16 articles were finally included in the review, all meeting the criteria in Table 2. At this point, 32 articles were identified for the literature list.

2.3. Analysis

After completing the search process, this study conducted a thorough evaluation and review of the 32 articles, reading through the titles and abstracts of the articles and then reading the entire text in depth, focusing on what was relevant to the research questions and recording the essential information and data from the literature to complete the data collection. This review used a qualitative approach, using content analysis methods to identify data on subjects, theoretical or conceptual frameworks, research methods, findings, and gaps in the literature, and thus address the research questions.

3. Results

3.1. Themes of the article

The review shows that current research is unclear about the definition and scope of the natural environment theme picture books; out of 32 articles, four articles focused on the natural environment theme in picture books of a particular period or award, and another five articles focused on specific areas mainly including animals (Ganea et al., 2014; Hooykaas et al., 2022), oceans (Francis et al., 2021), rivers (Aurélio et al., 2021), forests (Cho et al., 2022). Secondly, six were focused on Ecology (Martín et al., 2019), Eco literacy (Muthukrishnan, 2019), Life Science concepts (Zuhair et al., 2022), green behaviour (Mataram et al., 2021), environmental education (Chen, 2022; Munib et al., 2021) and picture books closely related to the natural environment. In addition, three studies focused on popular science books (Gao, 2022; Qi, 2021), textbooks (Boersema et al., 2001), and other children's books, mainly related to the different definitions in different countries or regions. On the other hand, the

design of picture books was explicitly discussed in 16 articles in this review, where ten studies focused on the overall design of picture books, which were usually conducted using mock-up books or picture books purposely designed for the study. The remaining studies each focused on a particular design element in picture book design, such as the images (Oberman, 2023) or illustrations (Aygün & Abacı, 2014; Brookshire et al., 2002; Ma, 2019), layout and typography of picture books (Huang, 2018; Yang, 2015)

3.2. Research methodology and theory

Regarding research methodology, seven articles were quantitative studies, which generally used surveys and observations and were conducted using tools such as questionnaires, coding forms, or scoring systems. Twenty-two articles of qualitative studies used methods such as observations, interviews, and focus groups. In addition, there were three mixed-methods articles (Gao, 2022; Ma et al., 2014; Yang, 2015).

Of the nine studies with children as participants (Figure 2), two articles chose preschoolers (Ganea et al., 2014; Muthukrishnan, 2019). Seven articles chose students in different grades of primary school to participate, with 1 study targeting students in grade 6 (Francis et al., 2021). The rest were for students in grades 1 to 3. Similarly, participation by preschoolers and younger students is usually accompanied by additional questionnaires or interviews with parents or schoolteachers.

From a theoretical perspective, most studies used cognitive developmental psychology, particularly Piaget's theory of stages of cognitive development, as theoretical frameworks or added concepts such as learning and cognition to them as conceptual frameworks (Anderson, 2013; Qi, 2021). Secondly, more articles used design theories or concepts such as design studies for support (Beeck, 2017; Matulka, 2008; Yang, 2015). In addition, some studies are based on theories of pedagogy, environmental education, preschool education, or adopt ecology, environmental science, environmentalism, and so on (Gonen & Guler, 2011; Muthukrishnan, 2019; Wang & Ji, 2022; Williams et al., 2012). However, all these articles are related to child psychology and cognitive development in some way, which is a theoretical background that must be addressed. In the discussion section, the authors delve into these theories in detail, examining how they guide the analysis of how picture books aid children in grasping ecological concepts and forming emotional connections with nature.

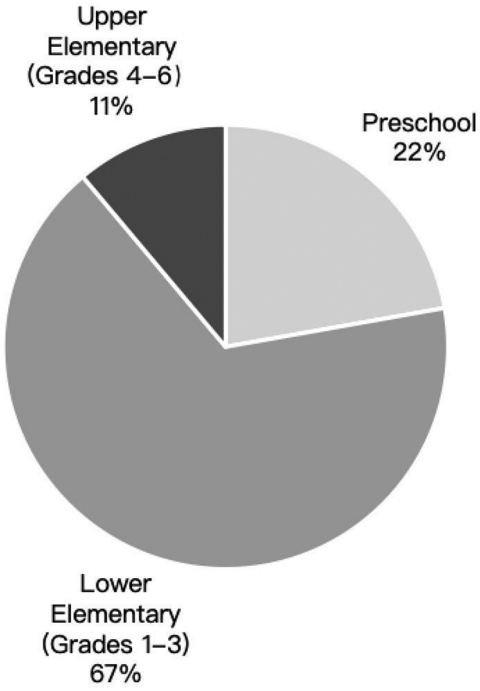

Figure 2. The distribution of children's age groups among nine articles.

3.3. Publication region and year

The range of articles reviewed covered a relatively wide range of countries and regions (Figure 3): 11 articles from China accounted for the most significant proportion, followed by Turkey (5), United States (4, including one collaborative study with the Canadian researcher), Australia (2), Indonesia (2), Netherlands (2), Taiwan (2), Iraq (1), Portugal (1), South Korea (1), and United Kingdom (1).

In addition, regarding the time of publication (Figure 4), 14 articles were published after 2020, of which 5 and 9 were published in 2021 and 2022, respectively. Seventeen articles were published between 2010 and 2020. Before 2010, only two articles were published in 2001 and 2022.

4. Discussion

4.1. Analysis of theories and concepts

This section analyses the theories and concepts used in the current literature to identify the main theoretical underpinnings of the current research. Of the 32 articles reviewed (Table 3), 15 had a clear

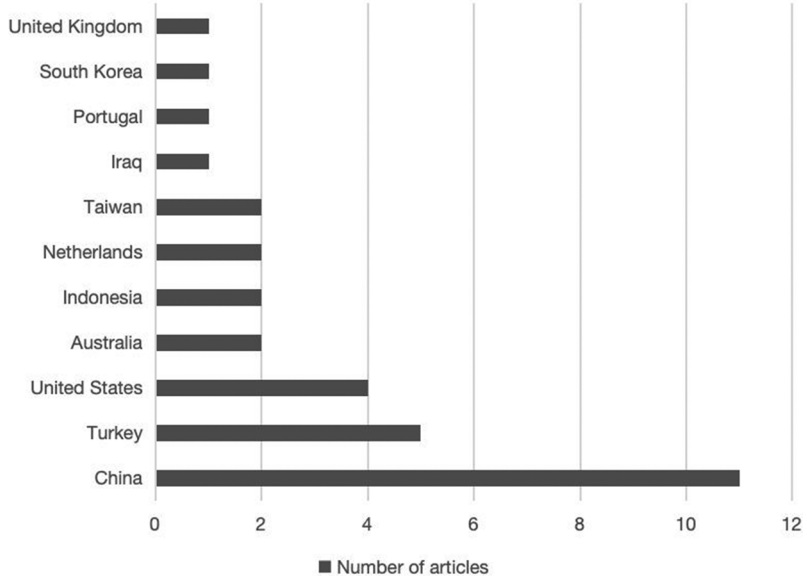

Figure 3. Number of articles by countries and regions.

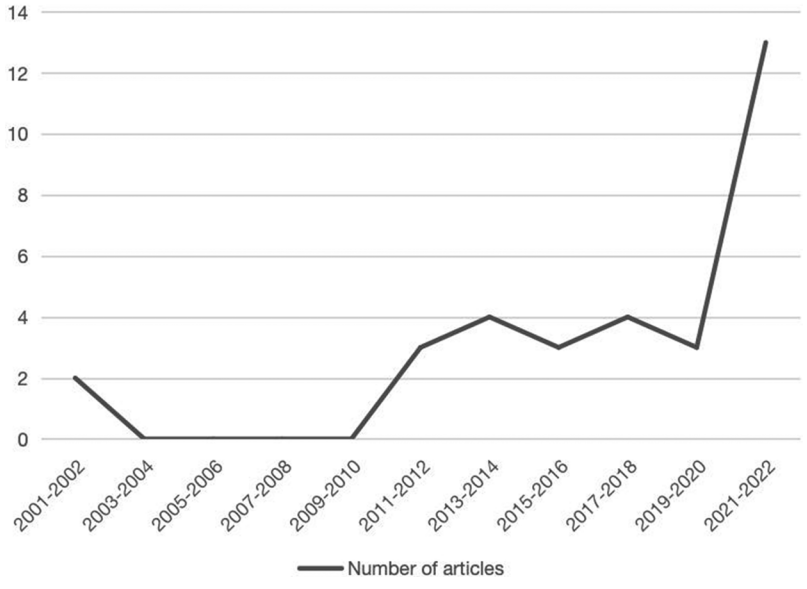

Figure 4. Year of publication of the articles.

Table 3. Relevant theories and concepts.

Subject	Theory or Concept	Total
Psychology	Piaget's Theory of Cognitive Development	4
	Cognitive Schema Theory.	12
	Piaget's Stages of Development	
	Cognitive Theory of Picture Book	1
	Attachment Theory	1
	Social Learning Theory	2
Pedagogy	Child-cantered Education	2
	Constructivist Theory.	3
	Vygotsky's Theory of Zone of Proximal Development	
	Education for Sustainable Development.	8
	Eco-Critical Theory	
Environment/Ecology	Environmental Science, Environmentalism, Green behaviour	4
	Ecology, Ecocritical theory	5
Design	Book design, Picture book design	3

theoretical framework, of which 12 were theoretically supported by cognitive developmental theories predominantly in psychology and three by ecology-related theories. The remaining 17 do not have a clear theoretical framework. When further analysed, 8 of the 12 articles were dominated by Piaget's theory of cognitive development, which accounted for the most significant proportion. The remaining four articles also centred on other cognitive development theories in psychology.

Notably, Rani Muthukrishnan (2019) cited the picture book theory of cognition and affirmed the theory in his study. The purpose of this theory was to explore the link between picture books and children's cognition by creating a theory of picture book cognition. The theory posits that picture books significantly impact children's cognitive development, particularly in areas such as visual perception, language acquisition, and concept formation (Kümmerling-Meibauer & Meibauer, 2013; Muthukrishnan, 2019). The following researchers have drawn to support their studies, such as the definition of picture books (Phekani, 2023), the function of picture books in education and reading to promote cognitive maturation in young children systematically (Nicolopoulou et al., 2024; Shi, 2022).

There are also six articles based on environmental or ecological concepts, studies of natural environment theme picture books, such as environmental science (Boersema et al., 2001), environmentalism (Williams et al., 2012), and green behaviour (Mataram et al., 2021), which are all based on the concepts of environmental science and ecology, but also the concepts of environmental science and ecology behaviour (Mataram et al., 2021). Finally, three other articles deal with concepts related to design studies with a focus on book design (Gönen M. et al., 2012; Mataram et al., 2021; Yang, 2015). However, it cannot be ignored that most of them used other theories or concepts to support their research, which shows that a single theoretical study is insufficient to support the research in this direction. Cognitive developmental psychology, particularly Piaget's theory of stages of mental development, is often used as the leading, supporting theory or concept, showing that the two are inextricably linked in the same direction (Anderson, 2013; Kümmerling-Meibauer et al., 2015).

Therefore, in the existing research on this topic, most researchers have based their research on children's cognitive development theories, focusing on Piaget's cognitive development theory and cognitive schema theory, followed by the picture book cognitive theory (Anderson, 2013; Kümmerling-Meibauer & Meibauer, 2013; Muthukrishnan, 2019**).** However, a single theory is not enough to support the research on this topic, in the case of picture books on the theme of the natural environment, some ideas of environment or ecology are inevitably invoked in the study, which is especially important in defining and categorising picture books on this theme, as well as the environmental elements in them (Cho et al., 2022; Martín et al., 2019).

According to Piaget's theory of cognitive development, children's thinking evolves through interactions with their surrounding environment, making nature-themed picture books especially effective in teaching environmental awareness (Gonen & Guler, 2011; Wang & Ji, 2022). These books provide children with both visual and textual representations of nature, helping them form cognitive models of ecosystems, conservation, and sustainability (Beeck, 2017; Williams et al., 2012). By fostering understanding and appreciation of nature, as well as cultivating critical thinking about ecological issues, the inclusion of environmental themes aligns with cognitive development theory, enabling children to develop environmental cognition and empathy (Muthukrishnan, 2019; Wang & Ji, 2022).

4.2. Analysis of research methods

As one of the indispensable aspects of research, the method is the part focused on in this review (Table 4). In summary, except for 2 of the 32 articles that focused on theoretical analysis, the remaining 30 articles mainly used case studies (25%), content analysis (21.87%), observation (18.75%), experiment (12.5%), interview and survey (6.25%), theoretical study (6.25%), in addition to the combination of interviews, surveys, observations, and focus groups (9.38%). It is worth noting that the eight articles that used case studies were all from Chinese researchers. They mainly analysed one or more picture books. The article's descriptions of the research methods could have been more accurate. Some of the articles were close to the observation or content analysis methods used by researchers in other countries or areas.

Specifically, most researchers use case studies, content analysis, and observation in their studies of picture book design styles, design elements, and other design details. They mainly rely on updating scales validated in previous studies, creating new data sheets based on relevant theories, and conducting preliminary data collection on the picture book samples. On this basis, the data were coded and analysed in depth to obtain further results.

Several of the articles followed and updated the rating criteria and scales from Rule and Atkinson's 1994 article, and all these studies referenced the scales for new research and largely continued and built on the research design of that article. Rule and Atkinson (1994) provided a framework for selecting ecologically themed picture books in their study. Based on constructivist learning theory, which emphasises the importance of learners constructing knowledge based on their own experiences, the study confirms that using picture books develops conceptual cognition and that children can learn to categorise and understand ecosystems, animals and plants based on their interactions with picture books. Most of these studies were conducted on picture books within a limited number of years, within a particular theme in the country, or a specific award list, for example, the extent to which environmental themes and forest education content were presented and linked in picture books (Cho et al., 2022), animal images and biodiversity in picture books (Hooykaas et al., 2022), trends in the presentation of trends of natural environmental factors in picture books (Babb et al., 2018), the way the environment is depicted in picture books and the changing trends (Williams et al., 2012).

In addition, in the part of the study focusing on the relationship between picture books or picture book design and children's cognitive development, four articles used a questionnaire-based survey method. All studies had an apparent age or grade limit, although the age level of the respondents of the survey varied. Some of the studies also imposed restrictions on gender (Aurélio et al., 2021) and region of origin (Brookshire et al., 2002) were restricted. In addition, four articles used the interview method. However, all of them were used in conjunction with other methods, such as surveys and observations. These studies simultaneously required the participation of their parents or classroom teachers as they used questionnaires or interviews in their studies with preschool-age children. The reason is mainly because preschoolers have limited cognitive and other abilities, such as language perception, and need adult assistance.

Finally, some studies conduct research through experimental methods, which mainly focus on a specific design element and a specific group of people and usually have a more extended research period. These research methods focus on measuring and getting feedback from experimental subjects through more specialised scales or more refined instruments, mainly focusing on picture book design and children's comprehension (Boersema et al., 2001), environmental awareness (Aurélio et al., 2021), ecological literacy (Muthukrishnan, 2019), and knowledge of animals (Ganea et al., 2014) among other research directions. It

Table 4. Research methods.

Methods	Total	%
Case Study	8	25
Coding and Content Analysis	7	21.87
Experiment	2	6.25
Experiment (Mock-up book)	2	6.25
Interview and Survey	2	6.25
Interview, Survey, and Observation (Mock-up book)	2	6.25
Observation	6	18.75
Observation and Focus Group	1	3.13
Theoretical study	2	6.25
	32	100.00

is noteworthy that in 4 studies, this study purposely created a mock-up book for the study and used questionnaires, interviews, and observations (Mataram et al., 2021; Munib et al., 2021) to obtain feedback data from the participants to control the variables more accurately and is a more intuitive method.

Studies utilising mock-up books often control variables like forms of images such as illustrations and photographs, colour schemes such as monochrome or full colour, and text-image relationships to evaluate their effects on comprehension and engagement (Mataram et al., 2021; Munib et al., 2021). These mock-up books are meticulously designed to isolate specific elements, facilitating the study of each element's impact on cognitive development and knowledge retention.

As Gonen and Guler (2011) and Muthukrishnan (2019) suggest, interviews provide rich, in-depth data, allowing researchers to explore children's emotional engagement with picture books and their resonance with concepts like environmental sustainability. Experimental designs, however, often yield more structured, quantifiable outcomes, such as knowledge retention and cognitive processing under controlled conditions. By using mock-up picture books, controlled experiments can quantitatively assess variations in design and their effects on comprehension and engagement. Findings from experimental studies and interviews can then be compared to gain a comprehensive understanding of picture books' effects on cognitive development and environmental awareness (Mataram et al., 2021; Munib et al., 2021).

In summary, the combination of interviews, surveys, and observation is an ideal method for studying picture book design and children's cognitive development. The research can be carried out more effectively using tools such as scales, questionnaires, and interview protocols from previous studies. In addition, in the case of picture book topics that still need to be clearly defined or clarified in terms of categorisation, preliminary data collection can be conducted through observation and content analysis to ensure the accuracy and credibility of the study.

4.3. Picture book design

This section focuses on the current article's research on picture book design, clarifying the design elements included in picture book design and their related discussions, which is necessary to clarify the focus and direction of the subsequent research.

4.3.1. The basic principles of picture book design

This review was conducted to identify the basic principles of picture book design through analyses. First, unlike illustrated books, where illustrations are subordinate, text and images in picture books are closely dependent on each other (Kümmerling-Meibauer et al., 2015). In other words, focusing on the text and images of picture books and the complex and close relationship between them is the main subject of studying picture book design (Huang, 2018; Matulka, 2008). Picture book design mainly includes the structure and content parts; the former is also known as the physical structure of the picture book (Gönen M. et al., 2012). In the current study, although there is a conceptual difference between the design of the picture book, they are all along the basic concept of the book design, which is the basic principle of the book design. The researchers concluded that the primary attribute of picture books is that they are a branch of books that cannot be divested (Beeck, 2017; Liu, 2009; Yang, 2015), this highlights that picture book design should follow basic book design principles, modified to suit picture books' unique attributes, where text and images jointly convey meaning.

Table 5 showcases the concepts of picture book design addressed by the articles in this review, which covers the elements of picture book design in current research. Of these articles, 68.75% (22 out of 32) were cantered on picture book design, while of the remaining ten articles, six articles mainly discussed the relationship between picture books and children's cognitive development, with only minor references to picture book design, and another four articles were content analyses of children's books and picture books; they did not involve a discussion of picture book design.

4.3.2. The integrated design of picture books

Of the 22 articles, the majority (59.10%) focus on the integrated design of picture books, and although they use different concepts, including design form (Ma et al., 2014; Mataram et al., 2021) and design

Table 5. Picture book design.

Design Focus	Design Element	Total	%
Structure	–	0	0
Content	Image	4	18.18
	Layout	1	4.54
	Text-image relationships	1	4.54
	Characterization	2	9.10
Technology	AR technology	1	4.54
Combined Design Elements	Layout, materials, and production process Image shapes, colours, text and media Design physical structures, content, and illustrations Visual design (text and images)	13	59.10
Interactive Experience Design	Multi-sensory experience design	1	
	Five senses experience design	1	
		22	100

prototype (Munib et al., 2021). The specific design elements they cover include the content parts, such as illustrations, layout, and text, and the physical structure parts, such as materials and media. In summary, these articles have studied the design of picture books from a holistic perspective based on the theoretical foundations of child psychology and children's cognitive development (Luo & Liu, 2022).

4.3.3. The content and visual aspects of picture book design

In addition to focusing on the overall design, eight articles focus on the content and visual aspects of picture book design. For example, studies on images (including illustrations and photographs) concentrated on image styles such as realism and abstraction and colour schemes ranging from monochrome to full colour (4). Research on layout (1) and text-image relationships (1) primarily addressed the spatial arrangement and interactive relationship between images and text. Finally, studies on characterisation (2) explored the anthropomorphic qualities of characters and the diversity in their visual representation.

In the current study, illustrations, pictures, shapes, and characterisation related to images are the most frequently studied design elements because of the richness of visual information they carry. This is mainly because the visual variables of picture books have a significant positive impact on children's interest in reading, with colour and illustration being the dimensions that have the most significant impact on children's interest in reading (Suraya et al., 2021), as well as one of the most appealing aspects to children (Aygün & Abacı, 2014). Therefore, early exposure to picture books is essential for constructing and increasing children's understanding of the world (Qi, 2021). They influence children's preference for picture books, their ability to comprehend stories (Brookshire et al., 2002), language development, and other cognitive abilities (Babb et al., 2018; Ma H., 2019).

4.3.4. The physical structure of picture books

For the physical structure of picture books, the current research has few studies explicitly focusing on them. They are only mentioned in the discussion of the overall design mode of picture books, which, in addition to the previously mentioned reasons for the focus, is also related to the production process of picture books, the limitations of printing technology, and the consideration of the production cost (Gönen M. et al., 2012). Regarding technology, some researchers have paid attention to new ways of presenting, such as e-illustrated books and emerging technologies such as AR (Augmented Reality) (Chen, 2022), trying to explore whether new technologies can influence students' environmental behaviour. In addition, some researchers have explored the impact of new design modes on children's behavioural and cognitive development from the perspectives of multi-sensory experience design and five senses experience design, discussing the application of different materials, three-dimensional structures, interactive devices, and even sound-generating devices in the design of picture books, and provides new ideas for the future design direction of picture books (Song & Liu, 2022; Zhang, 2022).

Most researchers focus on holistic or individual design elements critical for preschool cognitive development. Current research agrees that picture book design should align with children's cognitive, psychological, and physiological development. Children's cognitive skills (e.g. symbol and concept understanding), psychological growth (e.g. empathy), and even physiological abilities (e.g. attention) vary by age and

experience, making developmentally appropriate design essential (Anderson, 2013; Muthukrishnan, 2019; Qi, 2021). Such alignment ensures design elements support cognitive engagement, facilitate emotional connections, and enhance learning outcomes related to environmental education (Kümmerling-Meibauer & Meibauer, 2013; Wang & Ji, 2022; Williams et al., 2012).

4.4. Relationship between picture book design and children's cognitive development

In recent years, researchers have increasingly studied the relationship between children's literature, especially picture books, and children's cognitive development, examining the relationship from multiple perspectives. As Kümmerling-Meibauer et al. (2015) mentioned in their work, to understand how picture books help children's learning and development, it is necessary to focus on language acquisition, the child's cognitive development, emotional development, literary acquisition, and visual literacy.

Of the 32 articles reviewed (Table 6), 26 explored the relationship between picture books or picture book design and children's cognitive development. Notably, as this review focused on natural environment theme picture books, the highest number of discussions on the conceptual development of natural environments such as natural spaces, organisms, and ecosystems (11), followed by cognitive development (4), teaching and science learning (4) behavioural development (2), language development (2), emotional preferences (1), self-efficacy (1) and visual perception (1). Another three articles, based on cognitive development and other child psychology theories, explored picture book design in terms of children's colour preference, visual perception, and cognitive learning to enhance the quality of picture books to meet better children's needs (Huang, 2018; Li, 2017; Song Z., 2016). In addition, three other articles only focus on the analysis of picture books and do not involve exploring the relationship.

Research on picture books and children's behavioural development deserves special attention; the word-and-picture narration in picture books may reinforce existing environmental sensitivity, curiosity, and a sense of wonder (Beeck, 2017), influencing children's environmental behaviour. When children's environmental knowledge and values are improved, they are more likely to adopt responsible environmental behaviour (Chen, 2022)—specifically in picture book design. Zhang (2022) proposed a multi-sensory experience design for preschool children's picture books based on the theory of children's behavioural development, discussing various design possibilities, such as the dynamics of vision, the diversity of children's senses, and immersive experiences. Mataram et al. (2021) designed and produced model books on green behaviours to collect feedback from adolescents on environmental protection and green behaviours and then analysed the importance of picture books in inculcating green behaviours in adolescents.

In addition, Kümmerling-Meibauer and Meibauer (2013) state that picture books develop cognitive skills through shared reading and concentration situations. Therefore, there is a discussion about picture book design and language cognition, reading cognition, and story comprehension skills that cannot be ignored in this review. The specific characteristics embodied in children's picture books make them a potent vehicle for language learning (Dowdall et al., 2020; Murray, 2014). Moreover, this specific feature is text-image relationships (Lewis, 2001; Nikolajeva & Scott, 2013). Firstly, complementary text-image relationships in picture book design enable picture books to meet children's cognitive needs better (Huang,

Table 6. Picture book design and cognitive development.

Factors	Factors affected	Total	%
Image	Enhances emotional engagement and visual recognition; aids understanding of complex concepts.	26	81.25
Layout	Promotes sequencing skills and spatial awareness; enables smoother concept processing.		
Text-image relationships	Supports language development and schema construction; enhances memory retention and comprehension.		
AR technology	Improves attention and active learning; promotes behavioural development and cognitive engagement.		
Combined Design Elements	Supports holistic learning and development by integrating cognitive, emotional and visual engagement.		
Interactive Experience Design	Improves sensory perception and attention; supports conceptual and sensory learning.		
Cognitive Schema Theory	Picture book design should be consistent with children's psychological characteristics and cognitive development.	1	9.37
Piaget's Stages of Development.		2	
Piaget's Theory of Cognitive Development			
Content analysis of picture books only		3	9.37
		32	100

2018), enabling picture books to impact preschool children's education and development (Ahi et al., 2014). Second, illustrations have an essential impact on story comprehension and children's preferences, and it suggests that illustration style may influence children's likelihood of choosing books independently (Brookshire et al., 2002).

Therefore, developing a more targeted approach to picture book illustration design that incorporates children's cognitive developmental characteristics can improve the usefulness and science of picture books (Ma H., 2019). Overall, picture books' benefits in conveying meaning through text and illustrations can provide children with verbal and nonverbal scaffolding, leading to improved comprehension and learner autonomy (Wu, 2018).

5. Future research

This review highlights the link between natural environment theme picture book design and children's cognitive development. Despite growing research in this area, more emphasis should be placed on understanding the relationships between design elements and their alignment with children's cognitive, psychological, and physiological development. Future studies should integrate advanced methods such as eye-tracking technology and neuroimaging tools to examine how children process design elements and how these influence understanding and memory of environmental concepts. Additionally, Current research emphasises paper picture books' content and visual aspects, overlooking physical structure and new presentation methods. Technological advancements should be integrated into studies to explore innovative design modes. As digital picture books and augmented reality (AR) technologies become more widespread, future research should explore how these advances alter children's interactions with text and images and how they enhance or inhibit cognitive development and environmental awareness. Finally, existing research often lacks diversity in theoretical frameworks and specific focus areas; future studies should expand topics and incorporate interdisciplinary approaches.

6. Limitation

This study has three limitations. Firstly, the combination of keywords and database screening may have missed some relevant articles, and it is suggested that future studies expand the search. Secondly, focusing on natural environment picture books increased the workload and made it difficult to cover all subtopics accurately. Future research should focus on precise subtopics. Finally, limited knowledge restricts the direction of future research, but cross-field and cross-regional collaboration is expected to produce richer results.

7. Conclusion

This study reviews 32 articles, addressing a gap in systematic reviews of picture books with natural environment themes. This study comprehensively examines how nature-themed picture book design promotes children's cognitive development and environmental awareness. Findings show that design elements play a crucial role in enhancing children's understanding of complex environmental concepts, facilitating cognitive engagement by fostering conceptual cognition and creating mental models of nature, ecosystems, and environmental conservation. The study also confirms the importance of aligning design with developmental stages, as books tailored to Piaget's preoperational and concrete operational stages enable children to explore nature, develop visual literacy, and cultivate empathy for the environment. The connection between natural themes and cognitive development is vital in supporting children's ecological literacy and encouraging pro-environmental behaviours as they grow. In conclusion, this study underscores the need for picture books to integrate well-crafted design elements that are developmentally appropriate and thematically aligned with environmental education.

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No potential conflict of interest was reported by the author(s).

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