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THE VISUAL LANGUAGE OF CHILDREN'S POPULAR SCIENCE BOOKS: HUMAN-CENTERED DESIGN ACROSS DEVELOPMENTAL STAGES

LIN Yifeng
Shaanxi University of Science and Technology, Xi'an, People's Republic of China
linyf0604@foxmail.com

Popular science books for children aged 3–9 not only serve as tools for early science education, but also contribute to the formation of early cognitive experience. Their visual language, therefore, should not only be aesthetically pleasing, but also correspond to children's perception, attention, and comprehension at different developmental stages. From the perspective of human-centered design, this paper proposes an analytical framework of «cognitive stage–psychological characteristics–design elements» by drawing on developmental psychology and the learning sciences. It discusses age-appropriate design in children's popular science books from three aspects: book form, materials, and layout. The study argues that the visual language of children's popular science books is not fixed, but should be adjusted gradually in line with children's cognitive development. This paper seeks to clarify, at a general level, the relationship between visual language and developmental stages, and to provide a conceptual basis for further research.

Key words: *Children's science picture books, design optimization, interactive design, multiculturalism, child cognitive development.*

INTRODUCTION

With changes in children's reading ecology, popular science books have played an increasingly important role in early learning and have gradually become an important medium through which children encounter scientific knowledge and form initial understanding. The Science Curriculum Standards for Compulsory Education (2022 Edition) emphasize the early cultivation of problem awareness, inquiry-based practice, and scientific literacy [1]. International discussions of scientific literacy also stress children's ability to understand, reason, and make judgments in real-life contexts [2]. This means that children's popular science books should do more than convey knowledge; through appropriate visual organization, they should also help children enter the content and build understanding.

At present, several mismatches can still be seen in the design of published books. First, some titles continue to follow the conventions of adult book series, using small type, very narrow line spacing, and low-saturation color schemes [3], which reduce reading fixation and make key information harder to grasp. Second, page layout is often not adjusted to children's age-related differences in the number

of information units and the hierarchy of labels, which can lead to the loss of important information during reading [4]. Third, visual language is often overly standardized: within the same series, a single layout pattern and symbol system may be repeatedly reused, resulting in limited creative expression overall [5]. These issues ultimately weaken the book's ability to support children's scientific cognitive development and independent reading.

Against this background, this paper treats children's popular science books as an important interface between developmental stages and visual language. It discusses the age-appropriate needs of children aged 3–9 from three perspectives—book form, materials, and layout—and illustrates these issues through three examples: *Shine-a-light science picture book series*, *Ada Twist, Scientist: A Picture Book*, and *Space diary*.

PURPOSE

The aim of this paper is to adjust the visual language of children's popular science books in accordance with children's cognitive abilities at different developmental stages. To this end, it proposes a basic framework of «cognitive stage – psychological characteristics – design elements» to summarize age-appropriate approaches to form, materials, and layout in children's popular science books, and to provide a foundation for subsequent research.

RESULTS AND DISCUSSION

There is no single visual language in children's popular science books that can suit all age groups. As children's cognitive abilities develop, the focus of page organization, material qualities, and visual guidance also needs to change.

For children aged 3–5, reading relies more on direct perceptual experience. Children are usually first drawn to a clear visual focus, and then connect image and text along a short visual path. For this reason, books at this stage are better suited to small or medium formats, single-page focus, and close image-text arrangement, rather than complex pages that require repeated searching. *Shine-a-light science picture book series* (fig. 1), for example, uses light-based interaction to create a relatively clear path of exploration, allowing children to move naturally between «looking», «searching», and «discovering». This reflects younger readers' reliance on direct perception and a single path into the content.

By the age of 5–7, children begin to develop a clearer sense of sequence and can also handle simple causal relations. At this stage, the page should do more than attract attention; it should also guide understanding. Clear step relations can be built through modular organization, numbering, arrows, and a stable legend system, so that children know the reading order. *Ada Twist, Scientist: A Picture Book* (fig. 2) is a representative example in this respect. The relationships among images, text, and prompts are clearly organized, and the pages show evident narrative progression and information grouping. This helps children move from observation to understanding and gradually develop the ability to restate what they have learned in simple form.

The reading demands of children aged 7–9 increase further. At this stage, their sense of rules, classification ability, and capacity to integrate information have

developed more clearly. Reading is no longer limited to moving forward along a single path, but also involves searching, comparing, reviewing, and summarizing. Popular science books therefore need to provide stronger structural support, such as clear chapter divisions, stable column settings, margin cues, and consistent legends and terminology systems across pages. In *Space diary* (fig. 3), charts, handwritten-style text, page zoning, and added interactive elements work together to create a strong sense of structure. The pages remain engaging while also supporting movement across different units of information and gradually helping children build more complete connections between pieces of knowledge.

Taken together, these three stages reveal a progressive pattern in the visual language of children's popular science books. At the lower age level, page organization needs to be simple, focused, and low in cognitive load. In the middle stage, children rely more on clear process cues and traceable reading paths. At the higher stage, clearer hierarchy and navigation become more necessary to support more complex information processing.

Fig. 1. «Shine-a-light science picture book series» [6]

Fig. 2. «Ada Twist, Scientist: A Picture Book» [7]

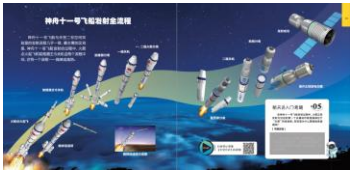

Fig. 3. «Space diary» [8]

CONCLUSIONS

From the perspective of human-centered design, this paper discusses age-appropriate visual language in children's popular science books for readers aged 3–9. It argues that the design of such books should not remain at the level of formal appeal, but should be grounded in how children actually process information. For children aged 3–5, a single focal point, close image-text proximity, and safe, perceptible materials make it easier to enter the content. For children aged 5–7, modular organization, explicit steps, and limited coding help support continuous understanding. For children aged 7–9, clearer page hierarchy, stable navigation, and structural use of color are needed to support searching, comparison, and integration. The three cases retained in this paper illustrate these differences to some extent. Shoudiantong Kan Limian Kepu Toushi Huiben is closer to the logic of direct exploration at the lower age stage, Ada Twist, Scientist reflects the process-based guidance needed by children in the middle stage, and Taikong Riji shows the tendency of page organization at the higher stage to move toward hierarchy and navigation.

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ЛІНЬ Іфен

ВІЗУАЛЬНА МОВА ДИТЯЧИХ НАУКОВО-ПОПУЛЯРНИХ КНИЖОК: ЛЮДИНООРІЄНТОВАНИЙ ДИЗАЙН У РІЗНІ ПЕРІОДИ РОЗВИТКУ

Науково-популярні книжки для дітей віком 3–9 років не лише слугують засобом ранньої природничо-наукової освіти, а й сприяють формуванню раннього когнітивного досвіду. Тому їхня візуальна мова має бути не лише естетично привабливою, але й відповідати особливостям сприйняття, уваги та розуміння дітей на різних етапах розвитку. З позицій людиноорієнтованого дизайну у цій статті запропоновано аналітичну рамку «когнітивний етап – психологічні характеристики – елементи дизайну», що спирається на психологію розвитку та науки про навчання. У роботі розглядається віковоvідповідний дизайн дитячих науково-популярних книжок у трьох аспектах: форма книжки, матеріали та макетування. Дослідження доводить, що візуальна мова дитячих науково-популярних книжок не є сталою, а має поступово змінюватися відповідно до когнітивного розвитку дитини. Метою цієї статті є загальне окреслення взаємозв'язку між візуальною мовою та етапами розвитку, а також формування концептуальної основи для подальших досліджень.

Ключові слова: *дитячі науково-популярні ілюстровані книжки, оптимізація дизайну, інтерактивний дизайн, мультикультуралізм, когнітивний розвиток дитини.*