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Babbling: A Digital Book Application to Improve Preschool Children's Social Communication Ability

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Abstract. Digital books provide a variety of ways to convey story content through the combination of images, text and audio. To effectively apply this combination to improve toddlers' positive self-expression and social communication abilities, though, relatively little experience and knowledge is available. We propose a "Users+" model to address this issue. By expanding the current design, we introduce the user into the design aspect of the application, replacing textual content with children's perception and interpretation of images. We investigated the "Users+" model's application using Babbling, a wordless digital book for kids. We explore the function of digital book applications in children's self-expression and interpersonal interactions and the value of the text for children's reading through a study of the behaviors and emotions of 20 preschoolers while reading. Thereby, we summarize three design strategies that provide a new insight into children's digital book applications that support user engagement and autonomy in design.

Keywords. Children's digital book application, user-driven design, self-expression, human-machine relationships

1. Introduction

The current penetration rate of children's Internet users is increasing. As of June 2021, the size of China's Internet users reached 1.011 billion, of which 158 million were under the age of 19, and those under the age of 10 already accounted for 3.3% of the overall Internet users. Current primary and secondary school students have gradually become accustomed to digital reading, and it can be said that we are now facing an era of digital children's reading full of technological fantasy [1,2].

Until then, paper books have been used to help preschoolers learn the written word and understand written content. When paper books were given new technology, digital books became a medium to connect children with others, their environment, and society. According to Montessori's research on young children, preschoolers aged 3-6 are in the sensitive period of language, order, senses, social norms and reading. Developing children's independence, confidence, concentration, and creativity during this stage can lay a good foundation for their growth [4]. Meanwhile, ages 3-6 are a critical period for children to learn language sounds, master basic grammar, and develop written language.

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External stimulation from reading builds and stabilizes children's brain structures, thus promoting their language development [5]. Thus, digital books can do more than developing children's literary skills. To some extent, it can also contribute to the development of children's social skills [3,6,7,8].

Although current digital book applications go to great lengths in terms of presentation and technical media, relatively little experience and knowledge has been accumulated on how to more effectively use a combination of graphics, text, and audio to enhance preschoolers' positive self-expression and social communication skills. At the same time, we aimed to extend the existing design, considering that the presence of game-like interactive features in the application could distract children and lead to poor story comprehension [9].

Our proposed "Users+" design model is derived from theories related to traditional print book design and the counterpointed triad technique to digital storybook apps [8]. The technical center of the design focuses on the combination of user, visual and audio, bringing the user into the design process of the application and replacing the textual design component with children's perception and interpretation of images. Using Babbling, a wordless digital book application, we applied the "Users+" design model. To enhance the design of Babbling app, we investigated the behaviors and feelings of 20 preschoolers during their use of the program and discovered a strong desire for active expression and sharing among preschoolers. Also, adults and environments provide additional value to children's reading experiences. Based on the findings, we discuss the role digital book apps play in children's self-expression, social cognition, and interpersonal relationships, as well as the significance of the text for preschoolers' reading. As a result, we propose three design strategies. It can provide new insights to support user-directed participation in the design of digital book applications.

The contributions of this paper include the following two aspects: (1) We propose a digital book application design model, the "Users+" design model, to support children's participation in constructing story texts and active self-expression. Although we focus our research on digital book applications, the pattern can be extended to other narrative-based interaction designs such as game design; (2) We summarize empirical knowledge about how children use digital book programs to express themselves and improve their language and social communication skills. It can provide some references for designers and researchers.

2. Background

2.1. Digital book and children's competencies

Digital books open a window into children's emotions and behaviors and provide knowledge about how society functions. Selected studies have demonstrated the critical importance of reading e-books for children's cognitive development and integration into society [10]. The visual, audio and interactive forms in digital books have narrative-enhancing features that can focus children's attention. Especially for children with underdeveloped attention regulation, digital books can respond to children's touch and enhance their memory of story content [11]. At the same time, it encourages children to be curious about new things and helps children to synchronize their narratives with visual information [12,13,14].

However, the variety of app platforms and mobile devices is growing, while the age

of children who can use mobile devices is decreasing. In the online cultural environment, children seem to be spending more and more time using apps rather than focusing on the content of book stories. In a study by Richter and Courage (2017), it was stated that 3-4-year old were unable to fully focus on paper books, while they spent far more time on interactive tasks with digital books than on reading [15]. This can largely negatively affect children's comprehension of story content [16].

The primary outcome that measures the quality of reading is children's narrative comprehension. It encompasses not only children's comprehension behaviors but also involves feedback on their emotions and behaviors. If digital book apps are not only a product of the times and trends, the question of how technology influences behavior will become more pressing after the digitization overload of paper books.

2.2. Digital book application design for children

In the digital age, theoretical studies and practical designs that use interactive features for children's educational purposes have become commonplace. Some of these digital book applications focus on children's reading and using experience. For example, in the Apple Store, app developers such as Toca Boca and JoyOrange focus on developing educational mobile applications for children. Each product is refined with children as the main focus by age and modular and incorporates touch control and gesture recognition technology in the reading process.

In addition, some digital book applications focus on promoting children's educational development through interactive features. In the "Polar Bear Horizon", children can see and hear word labels by touching the corresponding illustrations on the screen [17]. Through audio-visual means, children can receive and learn more vocabulary related to the story [18,19,20]. It can be seen that the design of children's digital book applications has been well developed, both in terms of presentation and the use of digital technology.

But the above researches place far more emphasis on children learning text than on developing their interests. When children passively receive knowledge and education, they are to some extent deprived of opportunities for active participation and output. With the aid of audio and text tasks, some children are constantly searching for possibilities to interact with electronic devices, while this interactive function leaves a steady loss of communication and response between adults and children [21]. Therefore, to maximize the added value of digital book apps for children, it is essential to accurately capture the meaning of the text for preschoolers' reading.

3. Babbling: the application design of children's digital books

3.1. The "Users+" design model

The concept of "Users+" design model comes from the new form of "Internet+" economic and social development, which is generated by Internet technology. Simply put, "Internet+" is the use of the information advantages of the Internet platform to optimize and upgrade traditional industries, thereby driving them to adapt to the new developments of the moment [22]. Similarly, the "Users+" design model is based on the needs of the user, and gives full play to the heterogeneity and plasticity of the user in the

application, thus forming a new form of application design development that is more personalized and proactive.

The "Users+" design model can be expressed on two levels. On the one hand, in the current design of digital book applications, some programs use a "symmetrical design" approach, where text, images, and sound display the same story content [6]. At the same time, an application design project uses "the counterpointed triad technique". It means that text, visuals and audio each display separate content, but work together to build the story [10]. The "Users+" design model builds on previous designs by introducing the concept of the user into the combination of images, audio and story, building a wordless book application. Since the user replaces the text, readers need to use their imagination to decipher the meaning of the book story and the corresponding interactive features. This facilitates the development of active readers who are committed to revealing the meaning of the narrative.

Figure 1. Symmetrical (left), counterpointed (middle) and "Users+" design model (right).

On the other hand, the deeper meaning of "Users+" as a whole concept is to complete industrial upgrading through the customization of applications. Incorporating user characteristics such as heterogeneity and plasticity into apps helps clarify the relationship between design and people. Meanwhile, incorporating children, adults and their environment into the design content of digital book applications can, to a certain extent, create more communication opportunities for children.

3.2. The "Users+" design model applied to the Babbling

Babbling is a digital book application for preschoolers aged 3-6. The introduction of the "Users+" design model aims to provide greater flexibility in children's reading, using a wordless combination of images and sounds to guide children in building story narratives and actively expressing themselves. Given these exploratory research objectives, Babbling has three design features that distinguish it from existing cases.

First, because the story content in existing digital book applications is established, with characters, colors, and story scenes already systematically written, children are unable to make choices based on their visual preferences. In contrast, the "Users+" design model is designed based on bringing the user into the design of the content and supporting children's immediate choices. In Babbling, children can independently select their favorite design elements, and randomly generate story images based on these components. The combination of non-deterministic design elements gives children the power to make their own choices. To a certain extent, it enhances children's motivation and willingness to engage in reading.

Secondly, in the "Users+" model, "text" is replaced by "user" and combined with images, audio, and story to build a wordless book system (Figure 2). Without the constraints of words, children can fully use their imagination to interpret the meaning of the book story and give it new narrative meaning. At the same time, the incomprehensible

and uncertain context stimulates children's curiosity and creates opportunities for social communication between children and adults.

Figure 2. Story interface of Babbling.

Thirdly, Babbling has explored a design approach that weakens electronics. Under the "behavior-feedback" mechanism, each story page in Babbling is a point of interaction. When children interact with the pages, it invariably increases the child's sense of control over reality. This early sense of confidence and satisfaction is important for the formation of children's self-personality. In the absence of text, Babbling guides children to look at the pictures and ask questions in an audio format. This will weaken the interactive function of playfulness. At the same time, Babbling transforms the reward for children who finish reading into an encouraging action for adults in reality. For example, when a child finishes reading, the screen shows an image of a cat giving a thumbs-up, and the audio prompts "You're great! Let mommy and daddy hug you".

4. Method

We validate the effectiveness of the Babbling children's book application through a user study of 20 preschoolers aged 3-6 years. Due to the epidemic, the study site was the home environment and children were accompanied by their parents to complete the study together.

During the research, the relevant behavior of each child was recorded on video. At the same time, the children's feelings were filled in a questionnaire with the help of their parents. In order to explain the different behaviors of children, we used the theme analysis method [23] to construct three central themes in the data obtained. It includes children's participation behavior, children's use feeling and children's response to adult intervention. On this basis, we used single-factor analysis of variance (ANOVA) and correlation analysis to explore the significant relationship between the issues.

5. Results and Analysis

5.1. Descriptive statistics and children's participation behavior

Almost all the children (90%) who participated in the survey have used electronic devices such as mobile phone or iPad. As part of daily life in the epidemic era, some parents read paper storybooks to their children almost every day or encouraged children to read independently (Table 1). During the use of Babbling, 11 children actively participated in this reading; 6 children participated with prerequisites; and 3 children expressed no interest in using Babbling.

Table 1. Descriptive statistics of the questionnaire.

Type	Options	Frequency	Percentage
Gender	female	11	55
	male	9	45
Age	3 years old	3	15
	4 years old	4	20
	5 years old	6	30
	6 years old	7	35
Children have used mobile phones or other electronic products	yes	18	90
	no	2	10
Parents have the habit of reading books to their children	yes	16	80
	no	4	20
Children have their habit of reading storybooks	yes	11	55
	no	9	45
Children have used book-related applications	yes	13	65
	no	7	35
Total	/	20	100

5.2. Children's feelings of use

According to the Likert scale, children's attitudes from "completely disagree" to "strongly agree" are marked as 1 to 5, as shown in Table 2. Question 1 (Mo =4，$\overline{x}$= 4) and Question 2 (Mo=5, $\overline{x}$=4.55) determined the usability of the application. It can be seen from the results that children were able to actively manipulate the application while the interactive instructions and functions were better understood. Questions 3-6 determined the children's level of mastery of the story content. Although the level of comprehension of the story (question 4, Mo=3, $\overline{x}$= 3.4) was not as high as expected from the study, most children were able to describe the content of the story relatively clearly and can express the meaning they wanted to convey (question 3, Mo=4, $\overline{x}$=3.95).

Table 2. Statistical tables of questions related to children's attitudes.

Title	Min	Max	Mo	$\overline{x}$	σ
1. I want to choose my favorite characters and colors	3	5	4	4	0.649
2. I want to operate my phone or iPad alone	3	5	5	4.55	0.826
3. I can describe the story	2	5	4	3.95	0.887
4. I can understand the story	2	5	3	3.4	0.940
5. Pictures or sounds help me understand the story	2	5	3	3.7	0.865
6. My parents helped me understand the story	2	5	5	4.1	0.912
7. I prefer e-books to paper books	2	5	5	4.05	1.099
Total	/	/	/	3.96	/

Table 3 shows that the age samples of children did not show significant differences ($p>0.05$) in their comprehension and expression of stories. In contrast, the mean values for both questions 3 and 4 exceeded 3, which implies that children aged 3-6 years were able to comprehend the picture and the content of the story by Babbling and paraphrasing it even in the absence of words.

Table 3. Descriptive statistics of the questionnaire.

Title	Differences	Sum of squares (SS)	Degrees of freedom (df)	Mean square	F	p
I can understand the story	Between groups	3.371	3	1.124	1.339	0.297
	Within groups	13.429	16	0.839	/	/
	Total	16.800	19	/	/	/
I can describe the story	Between groups	1.343	3	0.448	0.526	0.670
	Within groups	13.607	16	0.850	/	/
	Total	14.950	19	/	/	/

Table 4 shows that the correlation coefficient value between image or audio modulation and children's comprehension was 0.350, p=0.131>0.05, indicating that there was no correlation between the two. In contrast, the correlation coefficient value between the conditioning of images or audio and children's representational ability was 0.666 and showed a 0.01 level of significance, indicating a strong positive correlation between the two (Table 4). That is, Babbling's images and audio could help children to some extent to represent the images they saw, but to some extent, they could not support children to clearly understand the content of the story.

Table 4. Relevance of images or audio to children's understanding or expression of the story.

		Pictures or sounds help me understand the story
I can understand this story	correlation coefficient	0.350
	p	0.131
I can describe this story	correlation coefficient	0.666**
	p	0.001

* $p<0.05$ ** $p<0.01$

Table 5 shows that the correlation coefficient value between adult regulation and children's comprehension was 0.635 and showed a 0.01 level of significance, indicating a significant positive correlation between the two. In contrast, the correlation coefficient value between adult regulation and children's representational skills was 0.135 and p=0.570>0.05, indicating that there was no correlation between the two (Table 5). Thus, it can be seen that although adult participation did not play a real role in improving children's expressive skills, it could help children to further understand the content of story.

Table 5. The correlation between adult regulation and children's understanding or expression of stories.

		My parents helped me understand this story
I can understand this story	correlation coefficient	0.635**
	p	0.003
I can describe this story	correlation coefficient	0.135
	p	0.570

* $p<0.05$ ** $p<0.01$

5.3. Children's response to adult intervention

During the use of the Babbling app, some children tended to turn their electronic devices sideways toward their parents or give them to older children to operate. Also, during reading, they would constantly look at the parent, indicating that the children expected some relevant information from the adult in the discussion. For example, 5-year-old Jimmy (Figure 3) showed physical signs of excitement during reading, such as wiggling his body in delight. It is noteworthy that we expected children's comprehension of the story to improve after the expression or discussion. In contrast, some children showed more engaged verbal signs after reading, such as asking for parental input or refuting the older child's point of view.

Figure 3. The process of children using Babbling app.

In the statistics of children's responses to adult intervention, question 8 determines children's expectation of expression, and questions 9 through 11 determine children's level of confidence in expression. All of the above questions scored above the mean, especially question 11 (Mo=5, $\overline{x}$=4.7) was close to a perfect score, indicating that children have high expression claims and expect encouragement from adults. In addition, the large difference between the minimum and maximum values for each question item, except for question 11, suggests that children's attitudes toward adult intervention in reading are significantly different and require specific analysis.

Table 6. Statistical table of children's responses to adult interventions.

Title	Min	Max	Mo	$\overline{x}$	σ
8. I want to tell my mom and dad this story	2	5	4	3.35	1.040
9. I need mom and dad's help	1	5	5	3.35	1.461
10. I want to know if I am right	1	5	4	3.65	0.988
11. If my parents think I'm right, I'll be happy	4	5	5	4.7	0.470
Total	/	/	/	3.76	/

Table 7 shows that the sample of different children's ages showed significant differences at the 0.05 level for children's expressive expectations (F=4.772, p=0.015<0.05). The value of the correlation coefficient between children's age and children's expressed expectations was -0.648 and showed a 0.01 level of significance, indicating a significant negative correlation (Table 8). This shows that the younger the child is, the higher the expectation of expressing the story and the more he or she likes to actively express their self-opinion.

Table 7. Descriptive statistics of the questionnaire.

Title	Differences	Sum of squares (SS)	Degrees of freedom (df)	Mean square	F	p
I want to tell my mom and dad this story	Between groups	9.705	3	3.235	4.772	0.015
	Within groups	10.845	16	0.678		
	Total	20.550	19			

Table 8. Correlation between age and children's expectations for expression.

		Age
I want to tell my mom and dad this story	correlation coefficient	-0.648**
	p	0.002

* p<0.05 ** p<0.01

Table 9 shows that the sample of different children's ages does not show significance (p>0.05) for children's need for encouragement, implying that the attitude towards the need for encouragement shows consistency across ages. In contrast, there is a significant difference at the 0.01 level (F=5.852, p=0.007<0.05) between age and children's confidence levels. Also, the correlation coefficient between children's age and children's expressive confidence was 0.682 and showed a 0.01 level of significance (Table 10). This shows that the younger the age, the higher the level of children's confidence in expression, and also that parental encouragement is essential for children of all ages.

Table 9. Descriptive statistics of the questionnaire.

Title	Differences	Sum of squares (SS)	Degrees of freedom (df)	Mean square	F	p
I want to know if I'm right	Between groups	9.705	3	3.235	5.852	0.007
	Within groups	8.845	16	0.553	/	/
	Total	18.550	19	/	/	/
If my parents think I'm right, I'll be happy	Between groups	1.260	3	0.420	2.284	0.118
	Within groups	2.940	16	0.184	/	/
	Total	4.200	19	/	/	/

Table 10. Correlation between age and children's self-confidence.

		Age
I want to know if I'm right	correlation coefficient	0.682**
	p	0.001

* $p<0.05$ ** $p<0.01$

6. Discussion

The results of the above study showed that children were able to describe the content of the stories with the aid of images and audio, even without the guidance of words, and were able to express their understanding and opinions about the stories. At the same time, adult assistance enabled children to better understand the meaning of the stories. However, as children grow older, the breadth of key information they perceive during reading increases, their ability to acquire information develops rapidly, and the need to be able to express ideas correctly increases. To some extent, the lack of words affects children's self-confidence. This lack is compensated by the intervention of adults. The recognition, encouragement and guidance shown by adults during the reading process translates into a positive emotional value that increases children's confidence in expression. Thus, the inclusion of the user in the design process transforms the role of digital book applications. As a tool and instrument, digital book apps can help children build social and emotional bonds and foster positive socialization through user-directed engagement.

Based on the findings, we discuss a design strategy for optimizing digital book applications and the implications of this strategy for future research and design.

(1) Consider using children's participation and interpretation to expand the meaning of the story

We found that the absence of text prompts children to compulsively observe the images, which helps guide their attention to focus on the story narrative and actively think about the storyline, even to the point of expanding the story narrative with different content than expected. Therefore, the design of digital book applications requires not only images and sounds to set the mood and convey the emotion of the story, but also to allow children to give full play to their imagination.

(2) Consider supporting children's self-expression through adult intervention

Children's sharing can evolve as a social means of further engagement with the story, providing a self-directed entry point to the narrative content [8,24]. It has been shown that parental reading companionship can enhance children's reading ability, which is conducive to developing children's interest in reading and early reading awareness [25,26,27]. And wordless digital book applications provide the foundation for adult intervention. The process of children asking questions and expressing their views to adults is a process of deepening understanding and awareness. Such a reading model not only creates a relaxed environment for children to actively express themselves but can also play a role in increasing children's social awareness.

(3) Consider amplifying human-human interaction and weakening human-machine interaction

The interactive features of electronics are highly appealing to children, and supporting self-expression as part of this interactive experience is popular because it emphasizes the user's sense of autonomy [7,28,29,30]. Therefore, we proposed to use human-machine interaction as an entry point to amplify human-human interaction based on the previous design. For example, the story reading interface emphasizes the tactile

sensation of clicking and the fun of gamified manipulation. In addition to images such as thumbs up and sound effects such as applause when children complete reading tasks, the audio will guide parents to give children interactions such as hugs and kisses, building self-confidence and a sense of accomplishment for children while making them motivated for the next stage of reading.

Our findings can improve user engagement and initiative to some extent. It brings into play human subjectivity in digital programs through the active participation of users. However, there are some limitations. While most children are more proficient in using electronics, it is not a device that is regularly used in the home environment. Some parents also disapprove of children's early or excessive use of electronic devices and digital applications. Meanwhile, The study sample is subject to further expansion. With this in mind, the focus of our study was to provide designers with a qualitative understanding and experience of design.

7. Conclusion

Contemporary digital books offer a variety of ways to communicate story content. However, there is a need to further investigate how to effectively use a combination of images, text, and audio to enhance preschoolers' self-expression and social communication skills. We present a "Users+" design model that builds on existing designs by emphasizing the combination of children's perceptions and interpretations of images with images and audio to jointly convey story content and generate meaning from different perspectives. We explored the application of this model through the design of Babbling. Based on a study of 20 preschoolers, Babbling was shown to facilitate children's active communication and expression of their views with adults to some extent. Based on the findings, we propose three design strategies that aim to provide a new insight into the design of digital book applications with user participation in design and self-design.

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