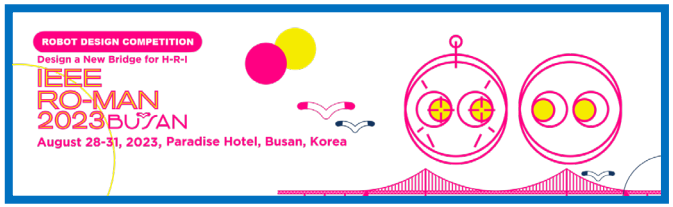
Book Toki : Interactive Reading Mate Robot



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This study aims to design an interactive robot to cultivate children's interest in reading. Unlike previous studies focused on robot functionality, this research explores novel human-robot interaction methods to engage children in reading. The target users are 5 to 8-year-olds who are starting to read aloud. Three design requirements were derived: 1) a robot with a familiar animal appearance, 2) animal-like movements, and 3) interesting reactions to trigger curiosity. The robot features a rabbit shape and responsive ear movements. As a child reads, the robot's ears change shape, metaphorically conveying "I am listening to you." It visually stimulates children and makes them feel like they read with a rabbit robot instead of reading alone. The robot's silicone ears bend and unfold using hydraulic pressure, while its head moves up and down with a linear stepping motor. The interaction method using metaphorical elements can be valuable for developing children's reading content.

1. ROBOTS IN CHILDREN'S READING

1.1 Boring Reading, What If with a Robot?

Entrepreneur Bill Gates said, "It was the library in my town that made me who I am today. What is more valuable than a Harvard diploma is a reading habit" [11]. As he said, reading experiences in childhood have a positive impact not only on lifelong reading habits but also on life in general. However, with the development of digital media content, the opportunities for contact with written media such as books are relatively reduced, and the number of children who feel burdened or not interested in reading is increasing [6]. Eva Hornecker emphasizes the significance of physical experiences in shaping perception, emotions, and cognition as living in a physical world. Interactions that involve physical manipulation have been shown to enhance the usability and enjoyment of a product or experience [3]. Therefore, this study aims to utilize a physically interactive robot in reading activities in order to help children feel fun and actively participate in reading books.

1.2 Related Robots

Existing research has shown that interacting with a robot in reading activities helps develop an interest in reading. Children who read with a companion robot reported that the activity supported their comprehension, motivated them to read, and made their social connection (i.e., friendship or sense of belonging) with the robot deepened [10]. In the case of "Luka," a robot that reads books to children, is an owl-like-looking AI robot developed by China's LingTech and is targeted at children between the ages of 2 and 8 who are not yet able to read on their own. By combining the camera and artificial intelligence, when the user places a pre-data book in front of Luka, it recognizes the book page and reads a fairy tale to the children. In addition to the functional aspects of robots, such as simply listening or reading, this study is meaningful in finding a new interaction method that makes reading more interesting and applying it to a robot.

Figure 1. Robot Minnie (left) and Luka (right)

2. USER RESEARCH

Before designing a robot, researching what age group it is specifically for and what the user characteristics are is essential in order to infer the latent needs of the user and guide the design in the interaction between the robot and the user.

2.1 Target User and Context

The target age group of children in this study is between the ages of 5 and 8. According to the research done by Cheon, children of this age are in the first stage of learning to read, and the activity of 'phonological reading', which is reading books aloud from spoken language to written language, is an important stage [2]. Learning to read at this age is the foundation for other curricular learning later [2]. The robot in this study is stationary on a desk within a 50 cm radius around the child where it can hear the child reading and the child can see the robot up close.

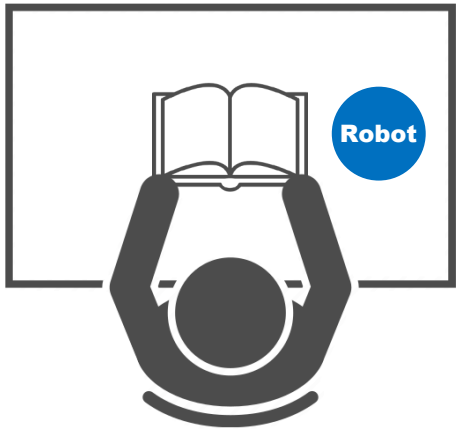

Figure 2. The Location Where the Robot Is Used

2.2 Characteristics of Users

Children between the ages of 5 and 8 are characterized by the following book-reading traits: First, children have animistic thinking [12]. Children of this age believe that anything that moves is alive, and that all inanimate objects have lives, thoughts, and feelings just like they do. Therefore, children of this age enjoy surreal, fantasy, and animal stories, and can even be seen talking to their dolls or the pillow they sleep on, giving them life [12]. Second, the internal factors that drive children to read include the stimulation of curiosity through reading [8]. Third, children are interested in reading if there is a positive interaction between the teacher and the student, creating an affectionate relationship [8]. Taken together, this study set the characteristics that a robot should have as follows.

1) A robot with a friendly animal image.
2) Attracting children's attention with life-like movements.
3) Stimuli that trigger children's curiosity (motion, reaction, etc.)

3. DESIGN DEVELOPMENT

3.1 Metaphorical Design

According to Heckel's research, metaphors in design serve to make a product or interface easier for users to understand [5]. In the past, the beauty and ease of use of a product were the central value of design, but now it has become more important to provide a pleasant experience through the use of a product or system. Especially in the field of interactive product design, which requires close interaction with users, metaphors can be utilized effectively [7].

3.2 Finding Metaphor

Figure 3. The Meaning-Object of the Metaphor

For a metaphor to be meaningful, there must be a similarity between the robot being designed and the object from which the metaphor is taken [1]. In Section 2.2, three main characteristics of robot design were presented through friendly animal image and motion. In this study, the meaning-object of the metaphor is a rabbit and the similarity as a metaphor between a rabbit and a robot can be found in the movement of the creature's ears pricking up when it listens to the sound or ears in the direction of the sound.

3.3 Details

Interactive products have three aspects: Function, Form, and Interaction [4]. In terms of these three aspects, the robot in this study has the following characteristics.

3.3.1 Rabbit Hole and Ears (Form)

In order to externally express the meaning of 'listening to the sound of children reading books', the external proportions of a rabbit with large ears were applied to the robot. Inspired by a rabbit hole in the fairy tale 'Alice in Wonderland', the robot sticks its ears out of a hole like a rabbit to listen to the sound of reading a book.

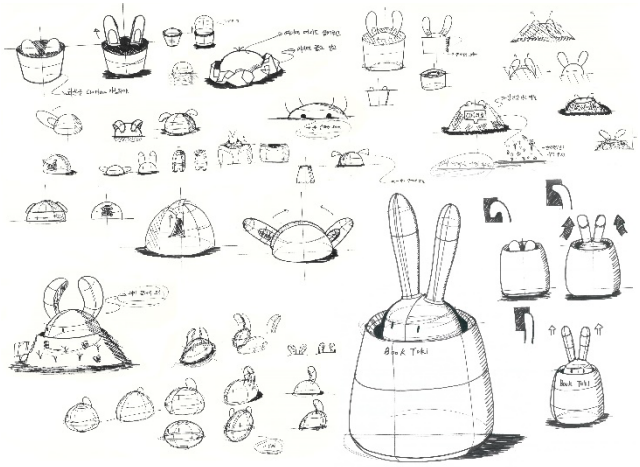

Figure 4. Thumbnail Sketch of the Rabbit Hole

3.3.2 Physical Changes over Reading Time (Function)

As the amount of time a child spends reading to the robot increases, the robot's head slowly comes out of the burrow and its ears gradually change from a bent state to an unfolded state. According to Altun's research, the average attention span of children

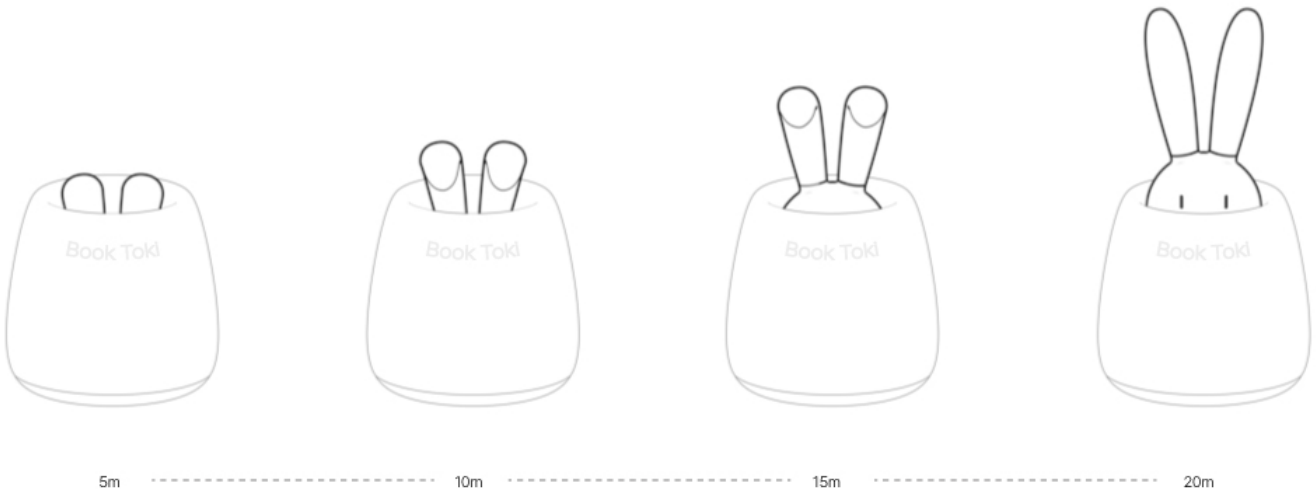

Figure 5. Changes in Ears and Head over Time

Figure 6. 'Book Toki' on the Desk

aged 5 to 8, the target age group, is up to 20 minutes [9]. Therefore, in this study, 20 minutes was set as the time when the robot's ears were fully unfolded and the face was visible the most. When a child stops reading, the robot's ears and head return to their initial state. The changes in the shape of the robot over time, such as 5 minutes, 10 minutes, 15 minutes, and 20 minutes, are as follows.

3.3.3 'I'm Listening to Your Voice' (Interaction)

As the child's reading time increases, the robot's ears gradually prick up and its head slowly rises out from the burrow. This intentional movement serves as metaphorical feedback, communicating to the child, "I'm listening to your voice." The visual stimulus created by these changes, combined with the semantic similarity, makes children feel they're actively telling a story to the robot, enhancing their reading experience and encouraging constant interactions.

4. IMPLEMENTATION

The key parts of the robot in this study are the head and ears. Constructing their drive systems requires careful consideration of two main factors. First, it is essential for the robot to operate silently, ensuring seamless interaction with the child's book reading without causing a disturbance. Second, the robot's movements should be smooth and slow, mimicking the natural motion of a rabbit and maintaining a constant speed for a duration of 20 minutes. For the vertical movement of the head, linear step motors are used. When the motor located at the bottom generates a rotational motion, the head, which is connected to the motor with a screw rail, moves up and down as shown in Figure 7.

The ears of the robot are made of silicone and achieve a natural bend when the ears are folded through the elasticity of the silicone. Inside the silicone structure, there is a hollow space that

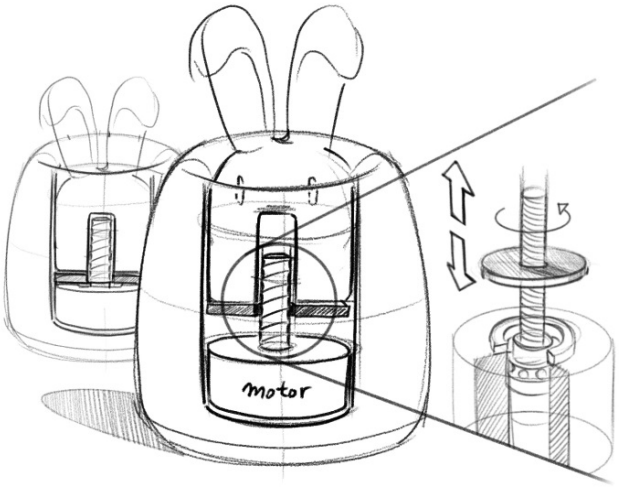

Figure 7. Structure of Linear Head Movement

creates the shape of the ears which can be controlled by injecting the liquid (water) using a cylinder as shown in Figure 8.

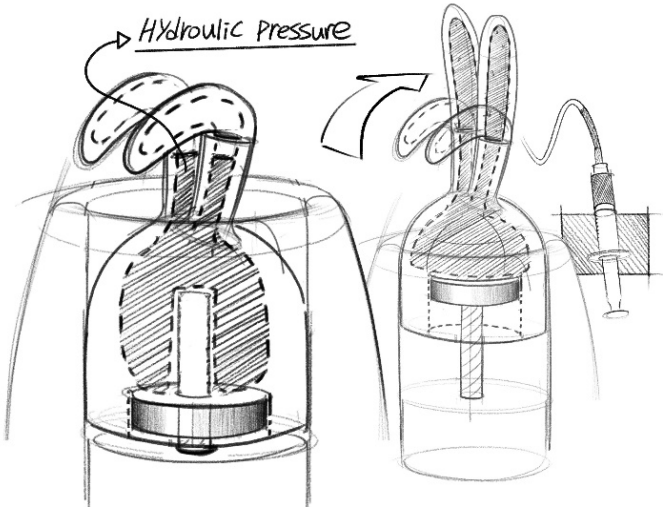

Figure 8. Control the Shape of Ears with Hydraulics

Apart from the ears, the other components of the robot are 3D printed using ABS for structural integrity and durability.

5. CONCLUSION

This study aims to explore human-robot interaction that engages children in reading. The target of this study is children between the age of 5 and 8 who are beginning to read aloud. To design a robot that aligns with the developmental level of this age group, the following characteristics are identified:
1) a robot with a familiar animal appearance
2) animal-like movements
3) interesting reactions to trigger curiosity.
In order to convey such features, the robot is designed as a rabbit, complete with large ears and a rabbit hole, utilizing metaphors of pricking ears and burrowing movements. As the child's reading time increases, the robot's head gradually emerges from the hole accompanied by the pricking up of its ears, symbolizing attentive listening. This metaphorical feedback, offering semantic similarity, provides a visually stimulating experience, fostering the feeling of story-telling to a rabbit robot rather than reading alone.
The robot's ears are made of silicone and hydraulics control its bending and extending degree, while the head employs a linear stepping motor for vertical movement. However, further research is required to delve into the internal design of the specification of the electronic component.
The study proposes a method of interaction between children and robots, incorporating metaphorical elements and a form of robots. This can serve as a reference for the future development of children's reading content and how robots can play a significant role in making reading a more enjoyable experience for children.

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