BrailleBlocks: Braille Toys for Cross-Ability Collaboration

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ABSTRACT
Less than 10% of blind people in the United States are Braille readers, yet Braille literacy remains crucial for education and employment [2,3]. BrailleBlocks is a system to help blind or visually impaired children learn Braille with a sighted parent. BrailleBlocks comprises a set of wooden blocks and pegs, each block representing a Braille cell, and an interface with games for parents. We conducted user studies with five sighted parents and six blind or visually impaired children. Children preferred games with sound effects, specifically Hangman and the Animal Name Game. Parents commended the system as a spelling tool and found the screen display of Braille letters to be a helpful reference. Children created new ways to use the system beyond the games we provided, like story-telling and stacking blocks into structures. We identified concrete ways to improve the system, including generating progress reports for parents and creating a portable version.

Author Keywords
Accessibility, blind, visually impaired, education, braille, children, collaboration

CCS Concepts
Applied computing~Collaborative learning

INTRODUCTION
Braille literacy in the United States is staggeringly low; recent studies have estimated that just around 10% of blind children in the U.S. are learning Braille [2]. However, learning Braille opens a rich and vast collection of reading materials and resources, enabling people to read when computers are unavailable or when listening to synthesized speech is impractical, such as in a noisy classroom [2]. Braille literacy has also been found to improve employment rate and reading proficiency [3]. Given these benefits, there is clear motivation to support people in learning Braille.

Assistive technologies have been previously presented as a means of promoting independence, but the design of some assistive technologies can lead users to isolating situations [1]. BrailleBlocks aims to address the isolating nature of Braille education by providing increased opportunity for collaboration, by enabling parents to play with and learn Braille alongside their child. It also presents a novel approach to learning Braille, by incorporating audio stimulation, tracking the tangible components with computer vision to check for accuracy, and using a game-based learning approach.

Figure 1. Two siblings placing pegs in the blocks to build letters. Their mom plays along with the laptop interface.

BrailleBlocks introduces an on-screen gaming system and physical block set to leverage the benefits of educational games and tactile learning. This paper will present an outline of the system, the structure of the user study, and the key takeaways for future development based on observations and participant feedback.

BRAILLEBLOCKS SYSTEM

Hardware
The components of BrailleBlocks are the physical blocks and pegs, the computer interface for parents, and an overhead webcam. The system includes eight wooden blocks, painted bright green, with six holes in each. Each block represents an individual Braille cell. A child makes a Braille letter by placing the pegs in the blocks, and assembles words by placing letters side by side. We chose red and green as high contrast colors, and to color detect the pegs using the webcam and OpenCV. The setup includes a frame in which the child places the blocks.

Games
The computer interface includes an Introduction section and three games: An Animal Name Game, Hangman, and Word Scramble. Each game shows visual representations of Braille letters as a reference and contains a "Check" feature that detects the pegs and displays what the blocks spell.

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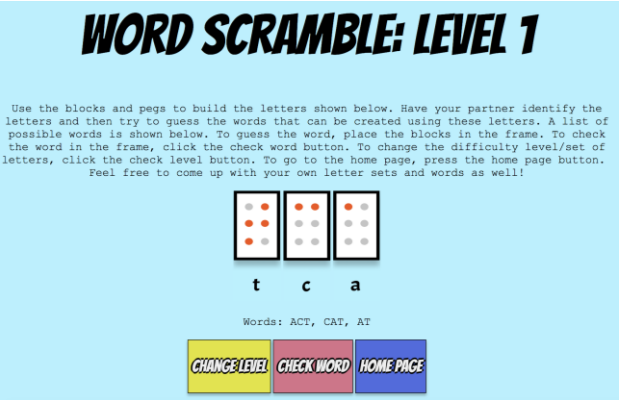

Figure 2. Level 1 of the Word Scramble Game. From here, parents can change the difficulty level, check what word their child has built, and navigate to the home page.

In the Introduction, parents can test their child on individual letters and orient themselves with the system. In the Animal Name Game, parents can play animal sounds and have their child guess the animal by spelling its name with the blocks. For Hangman, parents first enter a goal word. Their child can guess the goal word by letter, and parents can play the correct guess "ding" or the incorrect buzzer. Word Scramble contains five levels, each increasing in difficulty. Each level has a set of letters and a list of words that the letters can unscramble to form. The parent can create the unscrambled letters using the blocks and have their child feel the letters to figure out which words can be spelled.

USER STUDY

We conducted a design probe to observe how sighted parents and blind or visually impaired children collaborated and learned with BrailleBlocks. The study included five participant families. Four of the participant families included one sighted parent and one visually impaired or blind child. One family included one sighted parent and two visually impaired children. The children participants ranged in age from three to ten years old.

We conducted a one-hour exploratory session and interview with each participant family. The exploratory session centered around the games outlined in the System section. The participants played with the system at their own pace and picked the games they felt were most appropriate for their age and Braille level.

After the exploratory phase, we conducted an interview with the participants. We asked questions regarding their previous knowledge of Braille, thoughts on current Braille technology, and feedback on the BrailleBlocks system.

KEY RESULTS

Teaching and Collaboration

Parents developed several strategies to guide their children through the activities. Common teaching strategies among the parents included: 1) asking their child to recall the numbers that made up a letter in Braille when they were stuck or forgot how to build a letter and 2) hand over hand guidance. The latter strategy was reserved for when the child explicitly asked for help. The learning curve for the system varied among participants and some required more help with finding blocks within the frame and placing pegs in the holes.

During Hangman, parents adopted one of two strategies: have their child 1) guess the word by letter after giving them the number of letters or 2) guess a word based on a category and clues. Hangman and the Animal Name Game were popular among the kids for their allowance of guessing and use of sound effects, which the kids often enjoyed imitating. In Hangman, they were excited when they got the "ding!" for a correct guess, and giggled at the buzzer for incorrect guesses, which three of the kids likened to a fart.

During Word Scramble, children were often able to unscramble the letters, but sometimes struggled to join the letters together and say the word out loud. Four of the parents worked with their children to phonetically sound out each letter until they constructed the full word.

Creative Play

The kids (and siblings if present) would begin feeling the blocks before the study started, and often went to stack them into tall structures or place pegs in the holes. One participant thought the pegs looked like "raspberry gummies" and would build "sandwiches" by placing pegs in between blocks. At the end of the session, she stacked the blocks to build a house where the blocks were rooms, pegs were people in the house, and the cardboard frame was a train they would take to work.

Feedback and Improvements

At the end of the study, parents offered their feedback on BrailleBlocks. One parent suggested making the system portable for on-the-go learning. Two parents mentioned incorporating tactile markers on the block to orient the direction of the Braille cell and make it easier to find the holes on the block. Some parents suggested adding more auditory feedback to the system and the blocks themselves, like "having it say the letter out loud when I type it [into the interface]."

Many parents also expressed a desire for more stability in the physical setup, particularly with the frame. Three of the parents suggested integrating progress reports so they could track their child's learning. One parent suggested that BrailleBlocks "could plot data if she's identifying letters more correctly or more accurately [and] tracking how she's using her hands together."

CONCLUSION

During this study, we evaluated BrailleBlocks with families and identified key feedback for building collaborative Braille literacy tools. Documenting the creation and iterative testing of these systems will lead to new guidelines for accessible, affordable educational tools for blind children. In the future, we will use this feedback to design portable system for on-the-go learning, along with classroom deployments to observe how these tools integrate into curriculum in both mainstream and specialized classrooms.

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