Interactive number learning system for differently abled children

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Abstract: The focus of education for intellectual disabilities has shifted from solitary activity of providing care, into developing independent living skills for children with impaired cognitive learning. Dyscalculia being one of them. It is mathematical disability primarily amongst children. The proposed solution is an Interactive Number Learning System which helps affected children to learn and understand the meaning of numbers from 0-9. The activity entails both assistive and non-assistive learnings; to entertain, engage and encourage the child to think and play.

Keywords: Dyscalculia, Interactive system, Playful learning

Introduction

Differently abled children (DAC) can suffer from one or more impairments that interfere with cognitive functions. One of these can be Intellectual Development Disorder (IDD), as a condition it is characterized into mild, moderate or severe categories [1]. The study focuses on children with mild condition of impaired intellectual and adaptive functioning. Children with IDD can face difficulties in comprehension and inability to act appropriately on information and experiences. This happens because their illness can affect areas like memory, attention and concentration, ability of planning, experience of time, initiative and summing up of information. Within IDD, dyscalculia is a dire problem, and is similar to dyslexia.

Dyscalculia is related to mathematical understanding and logical ability of the affected child. A dyscalculia patient can have difficulties in identification of numbers, remembering basic mathematical facts and formulas to complete math problems. Dyscalculic's will be challenged by memory and retrieval difficulties [1]. Those who suffer with this disability have been known to comment that Dyscalculia causes numbers to "slip their minds," making numbers seem like an unknown language [3].

Evolution in electronics and computer technology has facilitated the foundation for expansion in learning as well as other assistances. Based on the literature review, it is evident that presently, technology is being integrated into functional areas e.g. communication, education, employment to benefit people with intellectual disabilities [5]. Our goal was to create playful, intuitive systems to enhance the intellect and learning abilities. The current paper describes the undertaken field study, its findings and design directions. Further proposing an interactive number learning system, enabling children to learn and understand basic numbers between 0-9.

Methodology and Findings

Please Data was gathered in 'Karuna' an NGO based out of Ahmedabad, Gujrat. The establishment provides special educational classes to DACs. These classes have a combination of teaching methods. We were part of a few teaching sessions, where we could observe the teacher - student interactions. These sessions gave us the opportunity to conduct activity based exercises with these children. Guided interviews of teacher, parents and doctors were also conducted to understand children's number learning patterns. Discussion with them gave an understanding of different learning and teaching methods that were currently used.

Teaching Methods

Family members, caregivers and teachers are involved in teaching children through active and passive modes of learning [2]. In active modes of learning the caregivers engage with the child, becoming a part of the teaching activity. Passive mode of learning can be defined by traditional teaching methods where the caregiver provides information but the child is required to interpret and learn himself [3]. Assistive and non-assistive teaching methods are used by the caregiver that can either be active or passive.

Assistive Teaching

Assistive teaching is a method in which the caregivers and teachers are continuously involved with the children. The caregiver gives a playful activity to the child to perform (Fig1 (a)). The child is monitored while performing the given tasks. If the child makes a mistake, he gets immediate attention and feedback by the caregiver. This continuous assignation engages the child and improves concentration. The assistive teaching method is effective as it is also a part of their daily behavioral training given by family members, for example eating, walking, speaking etc.

Non-Assistive Teaching

Non-assistive teaching is learning by self or learning via practice without physical supervision (Fig1 (b)). The caregiver provides an activity to the child, explaining him the task and asking him to perform the given task on his own. Child will be engaged with the activity without being monitored, this increments self-learning. Self-learning builds confidence and instills a sense of achievement but if the child doesn't complete a task successfully, he loses interest. Basic puzzle games and interactive toys are currently used by caregivers for non-assistive teaching.

a b

Fig. 1 Activities in the 'karuna' NGO.
a. Assistive Teaching b. Non-Assistive teaching

ISBN 978-93-5258-836-7

Continuous assistance and supervision can get challenging due to constraint of time or infrastructure. Similarly games and toys do not enthuse the child enough to continuously engage them. These were some of the challenges that immersed in current teaching methodology used. Assistive and non-assistive teaching methods are equally important and our proposed solutions are drawn from both the approaches.

Finding from user study

Analysis of field data revealed that every number has a unique characteristic and these characteristics were perceived by children differently due to lack of associative functions.

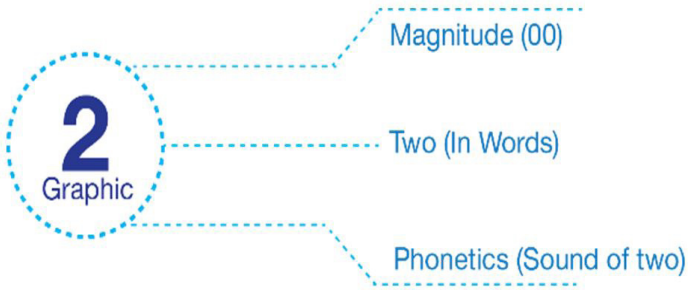


Fig2. Association of Number with different functions

Figure2 shows the relationship of a number with functional areas. Eyes perceive information through the visual cortex e.g. number 2 in words and graphical format. The phonetics of 2 is a frequency which is perceived by the ears and is processed through auditory cortex. For supporting the identification of a number the brain processes logical information like magnitude. Hence any number (e.g. number 2) is an association of all these perceived sensory and logical relationships. Uniqueness of this number is dependent on the outcome of information generated by the brains decision making area, after analyzing all these processes. We found that a dyscalculic child is not capable to forms these complex associations himself.

As number associations demand logic and decision making ability from the child which can get difficult for the DAC. Concentration and engagement are continuous challenges faced while number learning. In our study we observed that children are attracted towards colored lights, pictures, toys, games and music. Considering all the findings and observations we propose a playful number learning system to provide an assistive learning environment which helps DAC's to develop basic understanding of numbers.

Results and Solution

Here, we propose an interactive learning system which enables children to learn and understand basic numbers between 0-9. It was also observed from the field study that teaching DAC's is a slow process and they can't be taught by coercion. Keeping this in mind, we developed prototypes that were motivational and helped in self-learning. We have designed a learning system (Fig3), which is made with a basic network and low cost circuit assembly. A resister based sensor assembly is used to activate required message from a library. The

 ISBN 978-93-5258-836-7

developed prototypes play the voice of a particular number, display the magnitude and graphic of the number on the inbuilt screen.

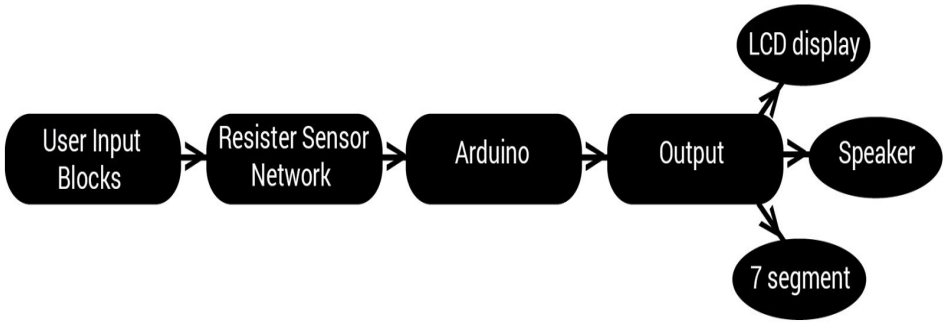


Fig3. Number Learning System flow diagram

Based on the similar structure we have designed multiple prototypes that can be classified into the following categories.

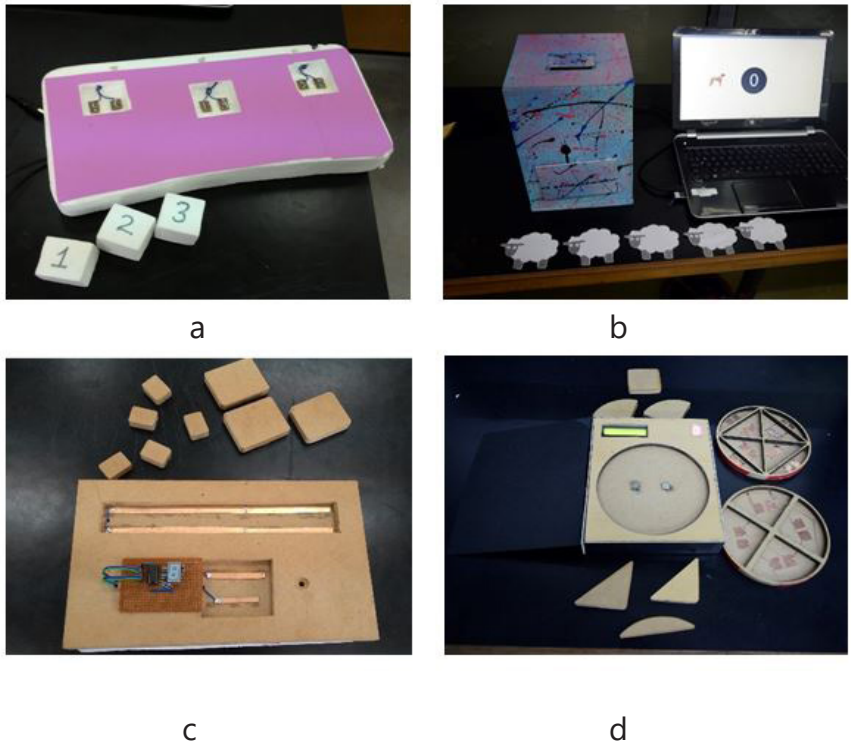
Improving Concentration & Engagement

A child with dyscalculia has a shorter attention span; hence it is hard to engage him for a longer period of time. It is difficult for the child to build concentration without being attracted or engaged. Therefore, we developed game prototype which encourages play rather than dissemination of information. As shown in Fig4 (a), negative spaces are mapped to specific numbers for example number one is mapped to the first negative space on the board. When the child places the square block inside the negative place, the device plays the sound of that particular number. The generated sound on completing the task is of applause which subsequently motivates the child. Specific colures were also used for visual feedback for example green indicates correct action.

Visual and auditory feedback emerged as important factors during first few user testing sessions. This learning helped design another prototype: 'cage game' Fig4 (b). In this game the child has to place a sheep figurine inside the cage. We introduced a counter to give visual feedback, mapping it to the number of sheep placed in the cage. The child further interacts with the system through a sound feedback which is that of a barking dog. The game encourages the child to play, which leads to superior learning results. The designed prototype gives visual and auditory feedback to catch attention, sustain engagement and enhance concentration levels in children.

Improving logic and decision making

In the next prototype, there were puzzle patterns with 4 or 8 blocks. Specific pattern arrangements give information through a combination of audio and visuals.



a b

c d

Fig 4. Prototypes of different stages

a. Basic block game b. Cage game c. Linear block game d. Puzzle game

There were two kinds of wooden blocks with size variations mapped to specific numbers Fig4(c, d). The board has two negative spaces which are mapped to these blocks, the child has to place the block in respective spaces to the figure out the number associations. This Information will appear on the display in a board, to assist the child in making the correct decision. Audio and display feedback provide several indicators to associate the magnitude of the numbers for examples smiles, figures and pronunciation. This concurrent information improves recall and number association.
Even though such a task is challenging for a DAC but through repetitive use, we hypothesize that this learning system will enable a dyscalculia child in logical ability and decision making. A validating exercise has to be carried out to validate our hypothesis.

Conclusion

The paper is focused towards basic number understanding rather than addressing intellectual disability as a whole. Traditional teaching methods sans technology can be seen as a major barrier today. Technology has the potential to act as an equalizer by enabling students with cognitive challenges to achieve their true potential. The proposed number learning system can be used as instructional aid for teaching DAC. Our study proposes a cost effective solutions without altering previous learning environments. The develop prototypes

need to be tested on field. Similar approach can be used to develop assistive educational environments through technology, for students with different intellectual disabilities.
In the future we would want to study a bigger user group for a longer period of time to understand many more challenges faced by DAC and their caregivers. This further understanding can help us developed numerous other games. These connected interactive games can be assembly based.

We strongly advocate design and technology are products of human creativity and imagination, subject to verification and functionality. The purpose of understanding social relevance is to influence technology to contribute and engage in society.

Acknowledgements The authors express their deep sense of gratitude to Dr. Jignesh Khakhar, coordinator of New Media Design, NID Gandhinagar, India and Dr. Daniel Ansari Professor of Neuroscience from Western University, London for giving their valuable feedback in the field dyscalculia and there importance in the learning, and also, for the NGO named Karuna in, Gandhinagar, India for their constant encouragement and support for providing me the access to re-search for this project.

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