Design for Difference: Cognitive Enhancement Toys for Children with Developmental Delays

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Abstract

Childhood is a phase where children explore, learn and enjoy. For some children, this phase is full of difficulties. These children suffer from either developmental delays or learning difficulties. According to sources, there is an iniquitousness of 1.5-2.5% of advancing delay in kids below 2 years of age in India. Development is described into five different domains - gross motor, fine motor, speech, and language, cognitive and socio-emotional. These children need help at an early age to overcome developmental delays and for cognitive enhancement. Both parents and teachers are involved with children right from an early age, and they can devise ways to help these children. Many schools adopt 'Play' as an important activity to help these children overcome developmental delays and "toys" are mostly central to the design of such activities.

The paper describes the design research for designing toys for cognitive enhancement of children with developmental delays between 2 and 5 years. In the first phase of research, the interview method was used to understand what kind of learning difficulties children face and what kind of methods are employed to teach them and understand what types of toys they are using. The sample size of 20 comprising of teachers, therapists, and pediatricians from Special schools and departments for special need children in mainstream schools was used for the interview purpose. Observational studies with children (5 different classrooms with children between 3-5 years age) were carried out to understand how children learn and use the toys. At the end of the first phase, the qualitative analysis led to the shift from learning difficulties to developmental delays. In the second phase, a survey of available products in the market was conducted to understand what types of toys are used to address these children's developmental activity. Mapping the play methods employed by the teachers and therapists to the toys' activities led to finding the Design gap. The design process incorporated the research findings. The product is designed in the form of a Toy Box with a multi-utility set of toys for cognitive enhancement in children with developmental delays. The design (three sets of toys) addresses children's communication, spatial, cognitive, gross motor & fine motor skills with developmental delays. The designed product was put through user testing twice to incorporate the findings from the testing to make the design more user-friendly for the children and the teachers, therapists, and parents.

1. Introduction

Childhood is a phase where children explore, learn and enjoy. For some children, this phase is full of difficulties. These children suffer from either developmental delays or learning difficulties. With the United States alone having a prevalence of 10%, India is estimated to have more than 10% of its children population having developmental delays and learning difficulties in coming years. Developmental delays could be symptoms of learning difficulties that are neurologically-based processing problems. At initial levels, they affect the academic learning abilities of children. As the children grow, they can further meddle with higher-level abilities, such as preparation, moments’ organization, reasoning, plus abstract thinking. Studying difficulties can affect these children's lives beyond academics and impact their relationships with family, friends, and colleagues. Learning difficulty is found across all ages and socio-economic classes. In countries like ours, it is still taboo to talk about developmental delays or learning difficulties [1]. Parents take a long time to acknowledge that their child could have a learning difficulty. Ignorance about it is prevalent, and it harms these children's development due to delayed intervention. These children need help at an early age to overcome developmental delays and for cognitive enhancement. Both parents and teachers are involved with children right from an early age, and they can devise ways to help these children. Many schools adopt 'Play' as an important activity to help these children overcome developmental delays, and "toys" are mostly central to the design of such activities. This research aims to find a gap for designing toys that serve as instructional tools for cognitive enhancement for children with developmental delays. This design research is qualitative and employs interview and observation methods [2].

2. Background

Learning difficulties is an all-inclusive word used to describe a wide range of learning problems in developing children. The term "Learning Difficulties" was first recommended in the Warnock Education Report in the UK in 1978, which describes these children with learning difficulties as special needs children. These children may have one or a few of these conditions: Dyslexia (problems with studying), dyscalculia (problems with Math), dysgraphia (problems in writing), and dyspraxia (problems with physical and mental skills). According to a study conducted...
by Jayanti Narayan and team, the deficits in these children may vary from seeing, hearing, and seeing-physical and mental activities to comprehending, recall, and focus. The children with learning difficulties face problems with learning pace in the schools. Their problems aggravate in schools since, more often than not, these learning difficulties are quite invisible [3].

3. Remedial Measures

In the last two decades, there has been much research happening in learning difficulties to identify and assess the learning difficulty and its level. A commonly understood method of identifying any learning difficulty is if the child is two levels below his normal level of attaining the activity (reading, writing, math, or involving motor skills), the child is regarded as having a learning difficulty. The investigations show that there should be a steady disparity of 2 grade phases or higher in single or higher educational subject fields to describe the kid as having a learning problem. There has been acceptance of these children's special needs in recent years, and schools are making efforts to cater to such children in mainstream schools. Also, many special needs children's schools have been set up to provide remedial teaching [4]. S. Ramaa and her team did extensive research with Indian children in schools to identify the specific difficulty, assess the level of learning difficulty and symptoms, and develop remedial measures that involved individual settings and small group activities in being applied in Indian conditions. Other studies also show that the children with learning difficulties often show disinterest in a study-oriented classroom setting. Since these children have conditions like impulsiveness, poor comprehension, inability to follow instructions, etc., an interventionist approach becomes more fruitful [5].

3.1. Role of 'Play' as Intervention Method

The early detection of learning difficulties leads to better intervention and instructional design for young children. It is observed that traditional assessment tools for children with learning difficulties often give an inadequate understanding of their skills and provide very scarce to significant training designs. In recent times, play has come to be recognized as an effective way of assessing learning difficulties. Through play, children demonstrate most of their abilities naturally, and toys are often central to such play settings.
Games give possibilities for getting several cognitive skills. Whereas the games are usually considered concerning casual sporting activities directed by the kid, games can likewise be academically centered, guided by the tutor or parent to arrive at particular academic purposes.

Many recent types of research explore the use of ‘augmented play toys’ against the normal observation methods for identification at early ages in case of a greater number of play functions. In their comprehensive research on ‘play’ as an assessment tool, Eisert & Lamorey discuss the growing interest of researchers in using play as a tool for assessment and, in their findings, suggest further investigation into ‘play’ as a tool for intervention and instructional design. This research gap is significant and can lead to findings that are useful for more play-toy-based instructional designs [6].

4. Primary Research

4.1. Interviews & Observation Studies

The research intended to find the required data for designing toys that can enhance cognitive development for children with learning difficulties. The primary research addressed the following research questions:

(a) What kind of learning difficulties children face?

(b) What kind of methods are employed to teach them?

(c) What types of toys are they using?

Since specific information about children was needed, which is qualitative, the interview method was chosen for question (a). A sample size of 20 comprising of therapists, pediatricians, and teachers from special schools and departments for special need children in mainstream schools was used for the interview purpose. The questions included what specific activities hampered in the children, what kind of difficulties are found in these children, and what kind of stimuli is needed [7]. The qualitative analysis of the interviews is shown in the combined table (Table 1).

A very important finding from interviews is identifying learning difficulty that cannot be diagnosed definitively before 7 in these children. However, developmental delays can be identified, and they may be symptoms of learning difficulties. Writing and Math Samples of Children from Observation Studies is indicated in Figure 1.
For questions (b) and (c), 'observation' method was chosen. Observation is a valuable method since it provides insights about play behaviors and mental representation in play and language contexts seen in these children. For observational studies, children between 3 and 5 years of age were chosen from five different classrooms from three schools to understand how children learn and use the toys. Observation studies for one session (40-50 minutes) were conducted. The average size of the class was 15 children. Observation also included the instructors/teachers, and Toy Samples from Observation Studies is indicated in Figure 2.

The overlapping contents from both interviews and observations were grouped, and inferences were drawn (Table 1). The problem area of learning difficulties is shifted to developmental delays inferring to the finding from the interviews [8].

Some important findings from the study:

- In almost all classrooms, no text books were used.
- Teachers designed their own learning material, game and activity.
The grouping of children in class is done according to the target learning area and based on their learning needs.

Each child has their curriculum.

Four learning styles were targeted: visual, auditory, kinesthetic, and tactile.

Too many toys throw children into inactive zone because of lack of stimulation.

At this point, since problem area shifted to developmental delays, for analysis, findings from both the interview and observation studies were grouped under five themes: cognitive, spatial, communication, gross motor & fine motor skills, based on the five domains of development in children: (1) Cognitive Development (2) Social and Emotional Development (3) Speech and Language Development (4) Gross Motor Skill Development (5) Fine Motor Skill Development. (http://www.howkidsdevelop.com/developSkills.html)

Table 1 - Theme Grouping of Findings from Interview and Observation Studies

<table>
<thead>
<tr>
<th>Themes</th>
<th>Specific activities hampered</th>
<th>Target Areas</th>
<th>Teaching methods employed</th>
<th>Toys used</th>
<th>Inference 1 (Interviews)</th>
<th>Inference 2 (Observation studies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS MOTOR</td>
<td>Grip, holding, lifting, &amp; moving</td>
<td>Gross Motor Skills</td>
<td>• Passing the Ball</td>
<td>• Big size Ball</td>
<td>• Toys that involve pressing.</td>
<td>• More exploratory activities are needed for Gross and fine motor skills.</td>
</tr>
<tr>
<td>FINE MOTOR</td>
<td>Grip, holding, picking, writing</td>
<td>Fine Motor Skills</td>
<td>• Sensory objects</td>
<td>• Soft materials</td>
<td>• Let children touch</td>
<td>• Sensory objects are quite helpful for muscle training.</td>
</tr>
<tr>
<td>COGNITIVE</td>
<td>Reading, math, &amp; comprehensio n</td>
<td></td>
<td>• Story telling</td>
<td>• Books</td>
<td>• Different objects and textures.</td>
<td>• Tong Activities and Play play was found to be successful with children.</td>
</tr>
<tr>
<td>SPATIAL</td>
<td>Gazing distances, gaps, heights, objects</td>
<td></td>
<td>• Learning Abstract concepts (taught through concrete concept)</td>
<td>• Story board, Flash Cards, Alphabet cards</td>
<td>• Use the strong point of the child. For ex: the child is not good at reading and writing, but is good at remembering. Then convert all the concepts to stories.</td>
<td>• Children directed to some activity through story telling can be more beneficial in learning.</td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td>Communicatio n &amp; expression</td>
<td>Social skills</td>
<td>• Color &amp; shape recognition</td>
<td>• Cards can be used in conjunction with other play activities.</td>
<td>• More toy requirements for preprimary level children.</td>
<td>• Ball play is helpful in spatial understanding.</td>
</tr>
</tbody>
</table>

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4.2. Market Research

After the interviews and observation studies, market survey of available Toys for developmental delays was done [9]. The sources included Specialty toy stores, general toy stores and online stores. Grouping of Market Toys is shown in Figure 3.

The toys from the market were grouped according to the themes and were mapped with the target areas. Findings (Design gap) of the market research:

- Most of the toys are made of plastic which is hazardous for children.
- Limited sensory toys and sorting activity toys.
- Limited forms of blocks.
- Limited toys for word recognition. Only flash cards available.
- Toys do not cover multiple target areas.
5. Design Concept

5.1. Explorations

Design exploration was done with the five themes in mind: Spatial, Gross motor, Fine motor, Cognitive, and Communication. Based on the inferences and findings from market studies, the toys were ideated and clubbed as per the target themes (Figure 5). Different forms of stacking blocks, fitting blocks, soft sensory blocks with press buttons, matchboard with fitting pegs, various stamps with textures, and flip board for word recognition and math activity were designed [10]. The material for the toy set was chosen as pinewood, as it is sustainable, lightweight, and non-hazardous for children. Design explorations for Toy are explained through Figure 4.
6. User Testing

The first set of Toy mock-ups (Figure 6) were then user tested. The mock-up toys were given to the same set of children who were part of observation studies. Each toy set was given to the children and observations recorded spanning 20 minutes [11]. The findings of the observations and the further design implications decided is shown in Table 2.
### Table 2 - Findings and Inferences of the First User Testing

<table>
<thead>
<tr>
<th>Themes</th>
<th>Toys Tested</th>
<th>Observations</th>
<th>Design Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>GROSS MOTOR</td>
<td>FITTING BLOCKS</td>
<td>The porous box and fitting blocks activity were very predictable for children and did not lead to any further learning.</td>
<td>Discard Fitting blocks toy since it is a level lower for the target group. (children of 2-5 age)</td>
</tr>
<tr>
<td>SPATIAL</td>
<td></td>
<td>Other set of fitting blocks were too difficult for the children to figure out since they all looked the same and children could not clearly distinguish between the tongue and its groove.</td>
<td>Discard these Blocks since they were way advanced for the target group.</td>
</tr>
<tr>
<td>COGNITIVE</td>
<td>STACKING BLOCKS</td>
<td>Children found stacking Blocks were interesting and easy to use and they could explore many activities and build different forms.</td>
<td>Go ahead with Stacking Blocks choosing the favorable forms.</td>
</tr>
<tr>
<td>SPATIAL</td>
<td></td>
<td>Children were trying to weigh and press/squish the blocks in their hands.</td>
<td>Use of both wood and silicone for the blocks so that children can learn the concept of weight and balance.</td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td>FLIP BOARD</td>
<td>Some children needed prompting from teachers to recognize and form the words. Teachers could create word and math puzzles using the squares by flipping.</td>
<td>Design Flash Cards to use with the puzzles.</td>
</tr>
<tr>
<td>COGNITIVE</td>
<td></td>
<td>Children were able to use the detachable alphabet and number squares easily and they were able to form words.</td>
<td>Go ahead with the Flip Board toy.</td>
</tr>
<tr>
<td>FINE MOTOR</td>
<td>MATCH BOARD &amp; TEXTURE STAMPS</td>
<td>Though children took interest in playing with this, the pegs were heavy for them to fit into the slots in the matchboard and they dropped them many times.</td>
<td>Discard Match Board.</td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td></td>
<td>The size of the stamp was too small for the children to feel the texture on it and soon they got messy with the ink. They also needed stimuli for the activity to be meaningful.</td>
<td>Discard texture Stamps.</td>
</tr>
<tr>
<td>GROSS MOTOR</td>
<td>SENSORY BLOCKS &amp; SORTING TOYS</td>
<td>The buttons and zippers on the Sensory blocks were hard to open as the blocks were too small to hold.</td>
<td>Discard Sensory Blocks but add them without buttons and zips to Stacking Blocks set.</td>
</tr>
<tr>
<td>FINE MOTOR</td>
<td></td>
<td>The beads in the Sorting toy were too small to lift with tweezer. Further, the act of picking beads became difficult since the sorting boxes were joined and gave too little space for movement of hands. Needed verbal/graphic stimuli.</td>
<td>Add different sized hard and soft beads to the Sorting toy. Design separate sorting boxes. Create a Sensory Puzzle on top of these separate boxes that will prompt children to pack the toys after use.</td>
</tr>
</tbody>
</table>
7. Design Development

Based on the first user testing observations (Table 2), further design implications were decided (Figure 7). Now, there is more overlap of the target domains for each toy. The Fitting blocks, Sensory blocks, Match board and Texture Stamps are discarded. Sensory blocks made of silicone (as silicone is easily moldable and non-harmful material for children) are added to the Stacking blocks. Also sponge blocks with different surface textures are added to Stacking block set. A handbook that includes flash cards and set of communicative stimuli for the parents/teachers is designed for Flip Board, stacking blocks, and sorting toys. Big and small-sized beads of different colors are added to Sorting toy [12]. Separate boxes are designed for sorting activity. A sensory puzzle is designed on the lids of these boxes that prompt children to pack the toy set.

8. Second User Testing

The set of Toy mock-ups developed after first user testing were given to the same set of children who were part of observation studies. Each toy set was given to the children and
observations recorded spanning 20 minutes. Interviews were carried in dyad sessions during user testing to validate the effectiveness of the toy set as well as the handbook [13]. Figure 8 shows user testing and product validation.

Figure 8 - User Testing and Product Validation

9. Result and Conclusions

The toy set was found to be used by the children with minimal difficulties. Children were able to stack the blocks and play around with the different weights and textures of blocks. Children could use tweezers and clips in the Sorting toy and sort the beads according to size and color on the instructions. The separate boxes were helpful in better sorting. The instructors were able to use the squares on the Flip board for alphabet effectively and word recognition, world-building, counting and simple math, providing stimuli with help of the handbook. The detachable pieces on the flip board were found to be easy for children to remove and replace [14].
The research was conducted to find the design gap of toys for children with developmental delays. The toy set addressed the domains of cognition, gross and fine motor, spatial and communication in these children; however, the design could address some aspects of developmental domains with toys, there is huge scope for research into how children learn using toys and how toys can be designed as instructional tools [15].

We have shown that children's video gameplay can create a new context for studying children's references to internal states. Children used ISL in both virtual and traditional play contexts. However, their speech about internal states differed in terms of the nature and referent of the inner states in the two contexts. Our findings have implications for parents, teachers, and researchers, who want to help children develop social understanding by encouraging conversations about their mental states. We discovered that children refer to internal states when playing video games. Thus, this popular activity could be targeted to support children's social understanding by encouraging their use of ISL. When parents and policymakers are concerned about children's screen time activities, our findings show that children demonstrate their social understanding and imaginative skills when playing video games, just as they do when engaging in more traditional forms of play with toys. Personalization of math word problems did not affect student performance, regardless of math, reading, WM ability, or enjoyment or cognitive load. Future research should concentrate on elucidating when, for whom, and why personalization affects mathematical learning, as well as ways to increase enjoyment and reduce cognitive load, particularly for lower-ability students.

Today's infants are the first generation of people who begin using digital devices almost immediately after birth, which provides researchers with an exceptional opportunity to study the development of user children in comparison to non-users, especially given that if current trends continue, identifying non-user children may become difficult in a few years. As a result, there is an urgent need for additional empirical research, including longitudinal studies, in light of the potentially long-lasting and widespread effects of device use on cognitive skills in children and thus educational, social, and later occupational functioning.

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