

DESIGN OF DESIGN OF LEARNING AIDS FOR CHILDREN WITH DOWN SYNDROME

T. Sooraj¹, H. S. Lohit², Mr. Vignesh Ravichandran³

1- M. Sc. [Engg.] Student, 2- Asst. Professor (DOD), 3- Asst. Professor (DOD)
Department of Design, M. S. Ramaiah School of Advanced Studies, Bangalore – 58.

Abstract

Children with Down syndrome deserve love and affection from our society. The chance of having a retarded child is so distressing and the causes are still so inadequately understood that most people naturally exclude the possibility from awareness. Moreover, culture does not have satisfactory rituals or practices for dealing with mental retardation. Current approach has traditionally been to abandon the mentally retarded as "impossible" and to eliminate them from society. Down syndrome children are totally dependent on parents even to do their daily routine work. The project mainly focused on fine motor skills and the result is a set of learning aids which enhance eye -hand coordination, grasping, rotation and manipulation of fingers especially for children with Down syndrome.

Design process involved primary research and an identified need for a set of learning aids to improve their fine motor skills. Data collection was carried out using Ethnography, Product study, Market study through methods such as questionnaires, interviews, images, videos and daily life observations. Quality Function Deployment (QFD) and Product Design Specification (PDS) were generated based upon data analysis. Issues and needs identified through data collection have been tackled in the developed concepts. Final concepts of learning aids have been selected by participatory and weighted ranking methods.

A 1:1 working model of the final concept titled "FINE MOTOR EXPRESS" which included five learning aids stored in a toy truck was built. Validation of the final concept has been carried out and feedback was collected from the users. It was found to be an effective learning aid for children to improve their fine motor activities. The concept also addressed the related usability and ergonomic issues. As an interactive design solution, the users were satisfied and showed positive response to the final design.

Key Words: Learning Aids, Down Syndrome Children, Aesthetics, Metaphor, Design research

Abbreviations

MR	Mental Retardation
DS	Down Syndrome
IQ	Intelligence quotient
NGO	Non-governmental organization
MDPS	Madras Developmental Programming System
QFD	Quality Function Deployment
PDS	Product Design Specification

1. INTRODUCTION

Children with special needs are children with a variety of different disabilities, health and mental health conditions that require special intervention, services, or support. Parenting a child with special needs can be particularly challenging. The definition of "special needs" is broad and includes health, mental health, developmental, and other kinds of conditions and diagnoses. Some examples include: autism, serious emotional and behavioural disturbances, mental retardation, attention deficit-hyperactivity disorder (ADHD), epilepsy, cerebral palsy, etc.

1.1 Mentally retarded children in India

There are over 30 million (3%) mentally retarded children in India, of whom hardly a fringe attend special schools or get vocational training. For vast majority there is no help because of the lack of resources. Mental retardation means substantial limitations in age-appropriate intellectual and adaptive behaviour. Mental

retardation refers to substantial limitations in present functioning. [1]

1.2 Children with Down syndrome

Down syndrome also called Trisomy 21 is a genetic disorder that occurs in approximately 1 of 800 live births. Children born with Down syndrome learn differently. They have more variations in their intellectual, language, and movement development. Children with Down syndrome usually develop fine motor skills in the same pattern as typically developing children but with some delay, reaching milestones later than their typically developing peers. They tend to decrease over time and, as they grow older, most children are able to achieve a perfectly adequate level of dexterity to enable them to participate in everyday life. [2]

1.3 Learning Aids for improvement of Fine motor skills

'Fine motor' refers to the development of small muscle movements in the hands, which require a child to manipulate and gain control over a range of materials and tools. Daily activities like open doors, button their shirt, pick up small objects, tie shoe laces, etc all are required fine motor skills to do these activities [3].

1.4 Specific relevance behind research

This project is aimed to conduct research on children with Down syndrome and to design a set of learning aids to develop fine motor skills. The project will mainly focus on small hand movements and the

result is set of learning aids which enhance eye – hand coordination, grasping, translation, rotation and manipulation of fingers. The design motto is to perform fine motor activities which comes in daily life like door opening and closing, button their shirt, pick up small objects, tie shoe laces, etc without others help.

2. PROBLEM DEFINITION

Mental retardation is not a disease; it refers to certain limitations in mental functioning and in skills such as communicating, daily self-care such as dressing or eating, and social skills. As per the estimation more than 30,000 babies are born with Down's syndrome every year in India. It is actually an obstructing factor for India like developing country. As a designer, it is our duty to give hands or some improvements to these growing children in terms of design perspective. The aim of the project is to design and develop learning aids for children with Down Syndrome of IQ 35-55 and age group 8-12 years to improve their Fine motor skills.

2.1 Project Objectives

- To carry out the literature review on the causes, symptoms and behavior characteristics of Down syndrome children.
- To collect design data of existing learning aids through product study, list of daily fine motor activities, ethnography and market study.
- To create QFD on basis of children interest, voice of stake holders and arrive at PDS to meet the various fine motor skills.
- To generate concepts as per PDS, create 3D models of the generated concepts.
- To build a series of prototypes of the concepts and take user feedback
- Modify the final concepts according to the feedback and make new full scale working model and user feedback.

3. PROJECT METHODOLOGY

- Literature review about Learning Aids for Down Syndrome children with reference from books, journals, patents, company catalogues and websites.
- Data collection will be done by ethnography schoolwork, product study, market study through methods such as questionnaires, interviews, images, videos and daily life fine motor activities.
- QFD will be created based on identified needs to turn up target PDS.
- Concepts of fine motor learning aids will be generated using sketching, ideation tools such as brain storming, mind mapping, theme boards.
- Number of concepts will be generated and modelled with detailed features using software such as CatiaV5, Alias studio tools, Adobe Photoshop.
- Rendering of learning aids models will be done using software such as Hyper shot and Key shot.

- Prototype evaluation for selecting the series final concepts will be carried out by children interaction, teachers and parent's choice as well as weightage ranking method.
- Final full scale working model was made with the correction according to the feedback and get validated.

4. LITERATURE REVIEW

Literature survey and review has been carried to collect data and understand about the children's with Down Syndrome and how their interaction has been takes place. It goes through children with special needs and the types of mental retardations. Survey focuses on day o day activities, which requires fine motor skills. And it narrow down to different learning aids which helps to do their daily activities independently.

4.1 Summary of Literature Review

- The literature reveals the characteristics, types, symptoms and causes of mental retardation.
- Mental retardation is a condition, not a disease and refers to an individual's level of intellectual functioning. It means substantial limitations in age-appropriate intellectual and adaptive behavior. [Psy Annals 27:3/March 1997][4]
- The major symptoms are failure to meet developmental milestones such as sitting, crawling, walking, or talking, in a timely manner. Also Decreased learning ability and ability to think logically, difficulty solving problems and inability to meet educational demands required by school.
- It was concluded that the main factors to cause MR are parental cause, before and after birth factors.
- IQ range for moderate retardation is IQ 35-40 to 50-55 as per Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) APA, 1994. [6]
- Trisomy 21 is the most common type of DS – around 95%, due to additional copy of chromosome in all cells- 21st chromosome. [Broman SH.(1987)][5]
- The DS children characteristics:- Short stature, flat facial profile, short wide neck, abnormally shaped ears, protruded tongue, poor muscle tone, learning disabilities, etc.
- There are several reasons why children with Down syndrome may have delayed motor development. These are cognitive, hypotonia, loose joints and ligaments and hand formation. [Sandy Alton (2009)][7]
- Fine motor skills include hand finger movements which include grasping, manipulating, and hand-eye coordination.
- The NGOs are funding for children with special needs and they are conducting many programs for giving awareness to peoples [8].

5. DATA COLLECTION, ANALYSIS & PDS

Product study, product environment study, market study and user study have been conducted for data collection. Data collection will be done by ethnography schoolwork, product study, market study through methods such as questionnaires, interviews, images, videos and daily life fine motor activities. As a part of data collection, Data collected through these primary research methods has been analyzed and utilized for proceeding steps. To create QFD on basis of children interest, voice of stake holders and arrive at PDS to meet the various fine motor skills.

5.1 Product Study

Stacking toy, wire bead maze, threading beads, profile matching puzzles, screw threading and lacing sneaker are the major learning aids or toys available in the market. The main motor skills of these aids are eye – hand coordination, visual tracking skills, improve fine finger movements like gripping & grasping, recognition of size, shape and colours and it develops control, concentration and self confidence.



Fig. 1 Product Study [9]

Here the concentration is given to the daily routine fine motor activities like opening and closing of doors, operating locks, bottle lid, gripping and grasping of small objects, etc. The products are latches, bolts, lock and key, bottle caps, nut and bolts, snaps and buckling and different clips. The different materials are wood, plastic, rubber, metal and fabric.

5.2 Product Environment Study

The learning aids are normally uses in special schools. The class rooms are the places where the children activities or learning's are mostly carried out. After school hours, they will be energetic in their home surroundings. Here we can feel that the interaction difference between these two places. In home they are most welcomed and having their own tastes and judgment to perform different activities. Habitual training centres and normal schools are also the platforms of these types of learning aids.



Fig. 2 Product environment study

5.3 Market Study

These are some listed educational toys or learning aids manufacturers in India. Actually there is no special manufacturer for learning aids, many companies are given a special segment for children with special needs. The main manufactures are Kidken (teaching aids and play school stuffs), Learners play (major role in wooden learning toys) and kidstuff (for improving normal lives). The price tag is based on the type, size and quality of the aid. In normal case it varies from Rs. 100 to 5000/-

Recently the leading manufactures are giving extra importance to eco friendly products, which gives more weightage than other plastic products.[10]

5.4 User Study

Gemba study conducted on special schools – Bethaniya special school, Rahma special school and Ashraya special school. All schools are deal with different types of students like DS, Autism, Dyslexia and Mild disabilities with varying age group and the classes are divided on the basis of student's mental age/ IQ. The examination will be carried out once in three months and the learning goal will be set according to the child improvement.



Fig. 3 Special schools

The Down Syndrome children are blessed with good imitating capacity while comparing other types, so with the help of continuous training we can develop them well. These types show caring nature and good in leadership qualities. Gross motor skills like use of large muscles are already achieved by this particular age group (8-12 years). Many children with special needs have challenges with their fine motor skills. Need to improve on Fine motor skills which help gain control on small muscle movements. From parents voice it is clear that it is very difficult to perform daily activities independently like opening and locking the door, picking small objects, small lid opening, etc.

MDPS Assessment: - [Reetha P, S. Venkatesan (1992)] [11]

It is a checklist used to assess the child mental as well as physical development. The activities like pick small objects, cutting paper with scissors, uses of lock and key, pouring water from one to another cup, stacking cups, etc. The overall assessment can be done in the basis of MDPS check list. The blue shaded regions are showing the achieved skills and red are want to attain in future. The teachers will conduct the test with the help of products which are using daily life activities. The grade will be given according to the performance like how they are behaving, handling, responding, etc.



Fig. 4 MDPS Assessment

5.5 Ergonomic Study

Ergonomic study is essential for design of learning aids. Mainly the interactions are takes place between the child and the aid, so care to be taken in the design profiles and dimensions. These dimensions will helps to the smooth and healthy interaction or involvement to the child. Children dimensions have been considered based upon the book "Anthropometry of Infants, Children and Youths to age 18 for Product safety and design" by Richard G. Synder. Here the selected age

groups are 7.5 to 12.5 years and the percentiles are chosen according to the maximum user's suitability.



Fig. 5 Ergonomic postures [Richard G. Synder. (1997)][12]

5.6 Quality Function Deployment

Quality function deployment has been derived by converting customer voice into technical voice. Attributes are prioritized and ratings are specified in order to define the relations between them. Higher priority essentials are listed in QFD analysis chart. The relationships between technical voice parameters are also rated at the top of the matrix in figure 6. The sums of each rating were computed and the technical attributes are to be prearranged more emphasis was formulated by analysis.

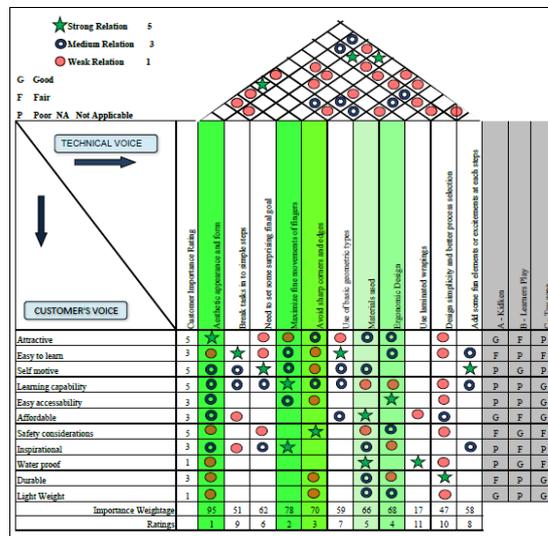


Fig. 6 QFD

A pie chart has been equipped from QFD data so as to know the main concern of each attributes and shown in figure 7. This helps in comparing the value of importance and prioritizing the technical voices attributes.

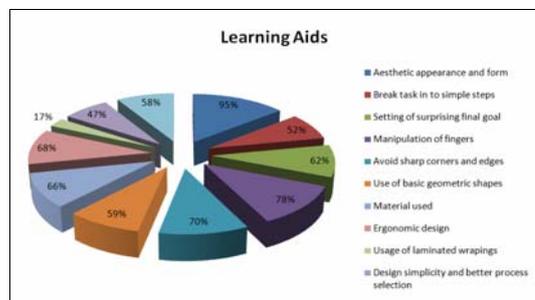


Fig. 7 QFD Analysis

5.7 Product Design Specifications

Product design specification gathers a range of requirements that have to be incorporated in the product. It can very well make sure that the user's objectives are satisfied.

Table 1. PDS

PDS for Learning Aids for Down Syndrome Children		
Sl.No.	Factors	Specifications
01	Product Name	Learning Aids for DS children
02	Purpose	To improve Fine Motor Skills
03	Area of use	Special schools, home , training centers
04	Target customer	DS children – age 8-12 years
05	Colours	Red, Green, Yellow and Blue
06	Materials	Wood,Fiber sheets, Nylon
07	Maintenance	If any breakage happens
08	Life span	5 Years
09	Aesthetics	Bright colors, abstract
10	Ergonomics	Ease in handling, pick and place
11	Quality	Durable, self motive
12	Manufacturing	Wood-carpentry, fabrication
13	Texture	Smooth
14	Interface	Physical interaction
15	Mounting	Table top
16	Safety	Round edges
17	Size	130x150x200mm
18	Weight	4 - 6kg
19	Disposal	Eco friendly materials
20	Cost	4000-4500INR

6. CONCEPT GENERATION

It plays an important role in development of any successful products. The concepts will explore many ideas and value additions also. The various design factors like literature survey, product study, market study, user study, etc have to be considered while generating the concepts. These concepts have been advance fine tuned and shortlisted to make 3D models in CAD software, Catia V5 and rendering software's.

6.1 Design Inspirations

Children's are always inspired by natural prospect and they are very eager to know the wonders. Taking into relation the huge organic variety on Earth, there is massive budding for innovative designs motivated by nature. As nature is a major source of all inspirations, which gives the real thriving force to drive the design process. It is very essential to have an outlook about the varieties of expressions in nature that can be incorporated in designing of learning aids. There are many types of expressions we can adopt from animals, birds, plants, etc which will give the real attraction, form and shape to the product.



Fig. 8 Design inspirations [13]

These are all the basic geometrical shapes which is well familiar to children. So the lines and joints will make the outer shape of the learning aids.

6.2 Mind mapping

Mind mapping has been used for concept generation by branching out the keywords such as aesthetics, materials, ergonomics, usability and environment.

6.3 Concept Generation

Concept sketches have been randomly generated from the derived PDS and visual elements. Some of the doodles are selected and further developed for better interpretation and fine tuning.

6.4 Concept 1 - Twister Square Stacker

The square stacker consists of different square blocks of varying sizes with key slot. The key slot entertains the child to do the action of rotation while stacking. The coloured faces help the child to identify the color and do the stacking as per side matching.

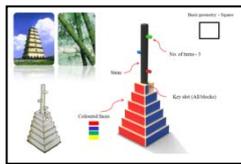


Fig. 9 Twister Square Stacker

Motor skills

- Eye –hand coordination and bilateral coordination.
- Improve ordering, sequencing, and counting.
- Develop the finger movements like flexion and extension.
- Recognizing shapes and sizes.
- Recognition of colours.

6.5 Concept 2 - Profile Round Stacker

The round stacker consists of round blocks with profile on down side. The profile facilitates the location and its shape is like circle fattened at two ends. The insertion is possible at two ways as per locator profile. The colour pattern gives concluding insertion direction. It matches vertically after completion of stacking. The motor skills are eye-hand coordination, gripping, manual dexterity,



Fig. 10 Profile Round Stacker

recognition of colour and shape, ordering and especially entertain the finger fine movements.

6.6 Concept 3 - Trapezoidal Triangle Stacker

This is a type of combination stacker with the usage of basic element triangle. The shape of the base is trapezoidal. The triangles can be arranged on two ways as shown in models. Here the method of stacking is little difficult than single column stacking. As per procedure the child need to stack horizontally like 3 triangles, then only they can move to next level. Here the child involvement will be more in these conditions like insertion, rotation and adjusting the triangles. This activity stimulates eye-hand coordination while teaching numbers, counting, and color and shape recognition.

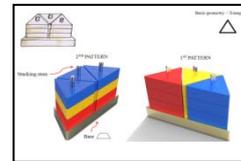


Fig. 11 Trapezoidal Triangle Stacker

6.7 Concept 4 - Octopus Bead Maze

Octopus bead maze is a type of bead maze; it consists of number of turns with several repetitions like 8 legs. The coil will give the path and direction and all are meeting in head portion.



Fig. 12 Octopus Bead Maze

The numbers of beads are arranged in counting wise like 1 to 8 with attracting 4 varieties of colours. The improved motor skills are eye-hand coordination, manual dexterity, gripping and sense of continuous profile tracking.

6.8 Concept 5 - Squeezer Drops

This exercise will give the practice to use the drops, especially for children taking drops regularly. With the regular practice, the child can improve the concentration and fine finger movements. It improves positioning and more control over fingers while performing the action of squeezing. Regular practice will help the child to perform the action without other's help. The tube sizes will decrease while going from starting to end, it helps to gain practice and increase confident level.



Fig. 13 Squeezer drops

6.9 Concept 6 - Guitar lacer

This learning aid is meant for give practice to shoe lacing. The task is divided in to three simple stages which help the child to learn step by step. The 1st stage is normal sewing on edges; it gives practice to holding and proper insertion. The 2nd and 2rd stages are directly shoot the cross lacing with minimum number of turns. Finally done with more number of turns as normal shoe lace carry out.



Fig. 14 Guitar Lacer

6.10 Concept 7 - Threading bow

The purpose of this learning aid is to encourage the practice of threading. It comes in daily life practice like opening and closing of bottles. This can be use it as an examination tool for children to check the ability or accessible level of threading practice. The task is easier on bigger sizes and needs training and quite concentration while goes on smaller sizes of bolts. It improves bilateral coordination, motor planning, eye-hand coordination and increases the attention and focus.

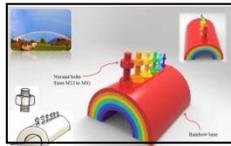


Fig. 15 Threading bow

6.11 Concept 8 - Human connector

The human connector consists of several rectangular blocks which can be assembled with the help of different connectors. Here the locators are type of connectors which are chosen from daily life practice, it gives the training to perform the same action without others help. The different colours are given on distinct faces, it helps to match the faces while in assembly time. The main fine motor skills are stability, bilateral coordination and sensation and dexterity.

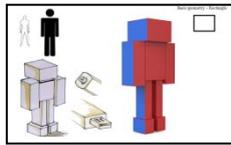


Fig. 16 Human Connector

6.12 Concept 9 - Clipping palette

Here there are two types of clipping aids are there, one is for power clip and other is paper clip. These practices help the children to perform the action of clipping independently. The small paper clips want more concentration and excellent finger movements, so it requires little time to pick up. The skills are fine gripping and grasping, pressing, color sorting, counting and sequencing.



Fig. 17 Clips

6.13 Concept Selection

Mainly the concept selection is based on the children's interaction. The choices are made easy with the help of children like how they are interacting with these learning aids.

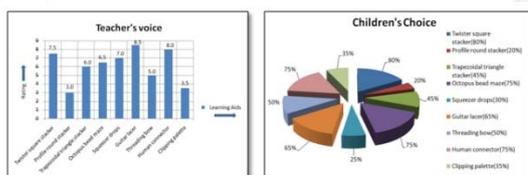


Fig. 18 Teachers voice and Children choice

The children's choices are twister square stacker, octopus bead maze, human connector, guitar lacer, trapezoidal triangle stacker, etc. Actually the children

are attracted with all learning aids and they have tried all learning aids also. The colours are most appealing for them to involve in this like doing the activities.

Learning Aids	Wt	Rt	Sc	Rt	Sc														
Aesthetics (Form & colour)	15%	5	1.25	4	1.25	5	1.25	5	1.25	5	1.25	5	1.25	5	1.25	3	0.75		
Finger movements	20%	5	1	4	0.8	5	1	5	1	4	0.8	5	1	4	0.8	4	0.8	5	1
Entertaining factor	20%	5	1	3	0.6	4	0.8	4	0.8	2	0.4	4	0.8	3	0.6	5	1	3	0.6
Skill sets	10%	4	0.4	3	0.3	3	0.3	4	0.4	4	0.4	4	0.4	3	0.3	5	0.5	4	0.4
Safety considerations	17%	2	0.3	4	0.6	2	0.3	3	0.45	4	0.6	3	0.45	2	0.3	3	0.45	3	0.45
Durability	10%	3	0.3	4	0.4	4	0.4	3	0.3	4	0.4	2	0.2	4	0.4	3	0.3	4	0.4
Total Score		4.28	3.85	4.05	4.2	3.65	4.1	3.65	4.3	3.65	4.3	3.6	3.6	4.3	3.6				
Decision		Develop	Discard	Develop	Develop	Discard													

Fig. 19 Weightage ranking method

The selected learning aids are

- Twister Square Stacker
- Trapezoidal Triangle Stacker
- Guitar Lacer
- Human Connector
- Octopus Bead Maze

6.14 Design of Truck

These are all some factors which lead to the design of truck. The storing system should have large enough to carry all learning aids.

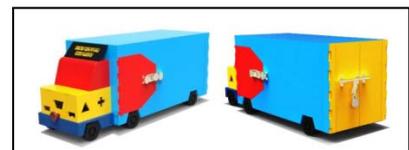


Fig. 20 Truck Concept

A vehicle model can itself is a learning aid for children's. They will be very eager to learn the things which are included. The truck is large enough to store and carry the learning aids.

Shape sorter on front fascia

The front portion is designed in such a way that it can have the additional entertaining factor like shape sorter. The three sides are occupied with basic geometric shapes and the opening is provided on front portion like bonnet. The cubes are stored inside the front cabin. Truck inside partition is designed in such a way that it can include all learning aids well in good posture. The main points emphasized while designing are



Fig. 21 Front fascia

- It can accommodate all learning aids.
- Minimum space utilization.
- Taking out and keeping inside itself a good exercise for them to perform as motor skills.
- The different racks in the truck are well designed to occupy the different learning aids. The shape will help the child to identify and store it accordingly.

7. DETAIL DESIGN AND PROTOTYPE

The detailed design can be made with the help of CAD software's considering manufacturability facets and dimensional particulars. It is necessary to work up on the selection of materials and manufacturing process to make ease of DFMA process.

7.1 Intermediate prototype model

An intermediate mock up model has been made out of thermocol sheets, card board papers for to know the children interaction. Based on that the number of learning aids are short listed to make final models.



Fig. 22 Intermediate prototypes

7.2 Modifications in selected concepts

There are some modifications made in concepts to rectify the problems.

Octopus Bead Maze

As per teacher's voice, arrange the number of beads in each coil as per counting wise. It starts from one bead in 1st leg and ends at 8 beads in last leg. It helps to enhance the counting skill (cognitive part) while beading. The square base requires improvisation. The round base will avoid sharp corners (safety consideration) while handling and it is good looking also.

Human Connector

The main problems are related with the assembly factors. The connectors are making problems to connect as in top down or bottom up assembly. The child interaction helps to rearrange the connectors in such a manner that it allows the easy assembly and dismantling. This modification will facilitate the easy assembly from bottom to top. The connectors are rearranged and individual legs joined together in this new model.

Trapezoidal Triangle Stacker

The screw mechanism is added to stack all the triangle blocks. The concept of threading bow is incorporated by the addition of nut and bolt mechanism. It helps to hold the block tightly while handling the stacker and the threading helps to practice the action of opening and closing the bottle cap.

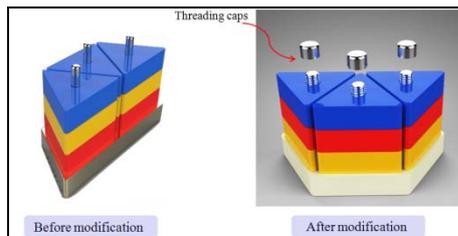


Fig. 23 Trapezoidal Triangle Stacker modifications

7.3 Detail Design

In these detail drawings it is already showed 3 images for each learning aids like assembly view, exploded view and detailed drawing. The exploded views help to understand more about the individual elements. In drafting it shows the outer major dimensions to know the rough size.



Fig. 24 Assembly view- Learning aids

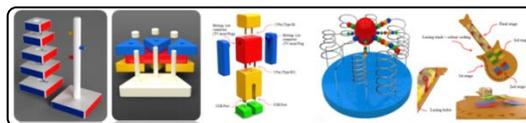


Fig. 25 Exploded view- Learning aids

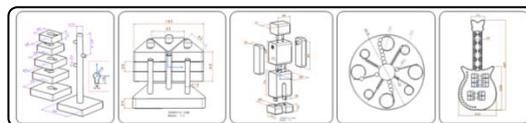


Fig. 26 Drafting- Learning aids

Truck Design

The different views of truck and the arrangements of learning aids are shown in figure 6.10. All the learning aids are arranged in such a way that it can store in separate racks. The doors are provided on two sides and the locking mechanism also like latches and locks. The child can interact with this mechanism and get things outside with the help of opening the doors.

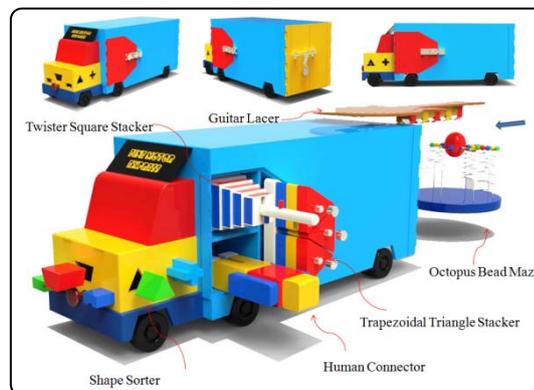


Fig. 27 Truck Detail – Rendered Image

7.4 Working model creation stages

It consists of sizing of blocks or sheets, performing drilling and slot making works, carryout fitting works, fixing hinges and latches and finally painting.

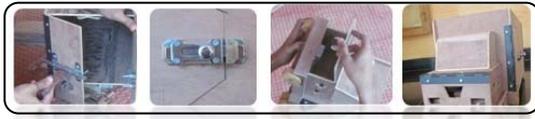


Fig. 28 Fixing latches, hinges

After the completion of all fitting works, the moving or rolling parts are needed to be fixed. Here the two doors are provided on side as well as back side of the truck. And third one is on front side and it is also an integrated part of the shape sorter. Hinges are fixed on sides to get the action of opening and closing. The split back doors are locked with the help of normal latch and lock and side with square profiled smooth latch.



Fig. 29 Painting – Learning aids

Painting is the final stage of model making. Before starting the painting, apply fine emery on all surfaces to remove the unwanted burrs it helps to clean the surfaces also. Initially it starts from applying primary coat on all surfaces. Here the white color paint act as a primary coat as well as it is a first-class base for all other shades. In figure it shows some painting stills. This is the final stage of model making; here the different shades are applied on surfaces according to our color scheme. Two coatings are required to get good glossy finish.



Fig 30 Final prototype model – Learning aids



Fig. 31 Fine Motor Express

In figure 30 shows the truck with all learning aids kept out side. The door opening of side as well as rear shows the working of truck doors.

Summary of detailed design and Mock up

The detailed design consists of assembly views, exploded views and 2D dimensional drawings. It helps to get the idea of all learning aids individual elements and the major outer dimensions. The basic material wood is selected for the making of learning aids. The manufacturing stage consists of sizing, making holes and slots and carried out the fitting works. Then following by painting works and detailing works including product name as 'FINE MOTOR EXPRESS'.

8. VALIDATION

Validation is necessary to taken up for to check or ensure the prospective of the final detailed design. In this case of learning aids the validation is carried out in special schools to know the interaction of children.



Fig. 32 Children interaction with model

These are some of the parameters and the comments of users while in validation of learning aids including the truck.

Aesthetics Parameters

- Children are very happy with these learning aids especially all are compiled in an attractive truck.
- The colours giving good attraction as well as motivation to start the activities, the major are using are red, blue, green and yellow.
- The curve holes pattern in the guitar lacer giving good desirability to lace the guitar.
- The colour braking in the hinge pattern and the side door profile is giving aesthetic appeal to the design of truck.
- The colours in the beads are arranged in such a way that the same pattern is repeating in all coils.
- Teachers indicated that, the colour coding in the guitar lacer is very attractive as well as directive also to do lacing operation.

Ergonomics Parameters

- Space between the coils is sufficient to move the beads comfortably in Octopus Bead Maze.
- Children can easy to hold the stacking elements like squares and triangles, sizes are giving fine grasping for them.
- The sizes of latches and bolts are selected in such a way that which are giving actual experience for them to operate these locking in terms of real size.
- The yellow colour in the shape sorter is easy for visual identification

Entertaining Aspects

- The twister square stacker scored maximum marks in this area; especially the most of the children are very interested in the way of stacking.
- The children are very eager to open truck and to take out all the learning aids inside it. The truck is act as a bunch of mysteries.
- Lots of colour choices or patterns are permitted to explore in trapezoidal triangle stacker.
- Finding or discovering the matching profile is very interesting for some children in shape sorter.
- Most of the teachers are happy with the abstractions or metaphors especially the coils in the octopus bead maze.

Manufacturing Aspects

- Wood is an excellent eco friendly material to manufacture the learning aids or toys.
- Water proof plywood is giving better choice to the manufacturing of truck exterior as well as inside partitions.
- Need to give more radiuses or round off to all edges and corners, which is not sufficient in present existing model.
- It is necessary to design the process and material for human connector; it is very difficult to incorporate all types of connectors in wood.

9. CONCLUSION AND FUTURE WORKS

9.1 Summary

The project is aimed as a synthesis of all the previous modules to learn about product development practice followed in design. Summing up of works carried out in the project work are

- Data collection through secondary research such as literature survey by referring books, journals, articles, patents and internet websites.
- Carrying the ethnography study to identify children's behavior and needs which is meeting in special schools.
- Product study to recognize the related learning aids and toys available and market study to discover the scope of a new product in present market scenario.
- Questionnaire survey among the parents and teachers and initial inputs from children.
- Customer voices have been analyzed to generate the QFD and targeted PDS.
- Majority of the Learning aids are abstracted from natural forms, which gives good supporting elements to emphasize the main character.
- Ideation includes mind mapping, doodling and random thinking processes.
- Intermediate prototypes have been made for all nine learning aids and the selection process was carried out based on children interest.

- Select the five final concepts through interaction with children and choose final through teacher's voice, weightage ranking method and design the truck for storing all these learning aids.
- 3-D modelling using Catia CAD software and rendering done in keyshot software.
- Full scale working model with detailing of truck and learning aids were made with the help of base material wood.
- Validation of the final model carried out in special schools considering aesthetic, ergonomic and usability factors.

9.2 Conclusion

The study models helped to get the idea of children's behavior and their interest. The types of stackers give the experience of stacking as well as recognition of colors. The beading can facilitate the fine gripping and movement of fingers through different coils. The splitting of tasks in guitar lacer rally helps the child to practice the shoe lacing in step by step manner like single cross to multiple crosses as well as color coding.

The need of truck was raised on the behalf of proper storing of all learning aids. Proper identification and sorting of shapes can be carried out by the shape sorter which was provided on the front side of the truck. The children can able to use the types of door opening systems which incorporated in the truck. It truly gives the real experience to the users where they can perform the operations independently in their houses.

9.3 Recommendations for future work

Some of the further necessities which can be considered for future works are listed

- Better choice of material and process selection for mass production of learning aids especially the Human connector and Guitar lacer.
- Patenting the idea of learning aids including the truck.
- Branding of the product with a Logo and marketing strategies.

10. REFERENCES

- 1] Anon (2012). Mental Retardation – India Development Gate Way [online]. Available from<<http://www.indg.in/health/mentalhealth/mental-rtd>>, [5 October 2012]
- 2] Anon (2013) Down syndrome. DermNet NZ [online]. Available from<<http://www.dermnetnz.org/systemic/down.html>>, [20 January 2013]
- 3] Mary Benbow (1999) American Occupational Therapy Association [online]. Available from <www.superduperinc.com/121FineMotorSkills.pdf>, [10 October 2012]
- 4] Van R.Silka,MD and Mark J. Hauser, MD (1997) Psychiatric Assessment of the Person With Mental Retardation [15 November 2012]
- 5] Broman SH.(1987) Prenatal Risk Factors For Mental Retardation In Young Children, Public Health Rep. 1987 Jul;102(4 Suppl):55-57.

- 6] Wechsler, David. Wechsler (1997) Adult Intelligence Scale Third edition Psychological Corporation, [20 November 2012]
- 7] Sandy Alton(2009) Learners with Down syndrome [online]. Available from <<http://www.downsyndromevictoria.org.au/...>>, [28 November 2012]
- 8] Thakur V. Hari Prasad(1999) Enabling the Disabled, Published by Thakur Hari Prasad Institute of Research and Rehabilitation for the Mentally Challenged,[30 November 2012]
- 9] Anon (2012) Stacking & Sorting Toys, Learning Toys, Toys:Target[online]. available from<<http://www.amazon.com/b?ie=UTF8&node=19660>> [1 December 2012]
- 10] Anon (2012) Learning Aids Manufactures in India - Special Needs [online]. Available from<<http://www.alibaba.com/showroom/special-needs-ed>>, [2 December 2012]
- 11] Reetha Peshawaria and S. Venkatesan (1992) Behavioural Assessment Scales for Indian Children with Mental Retardation, National Institute for Mentally Handicapped.
- 12] Richard G. Synder. (1997), Anthropometry of Infants, Children and Youths to age 18 for Product safety and design. Highway Safety Research Institute – The University of Michigan Ann Arbor Michigan 48109
- 13] Anon (2012) gadgets images [online]. available from<<http://www.google.co.in/search?q=natural+inspirations&hl>>, [3 December 2012]