Project 1
Summer Internship Report

Trivikram

M.Des, Product Design

2013-2015

Industrial Design Centre

Indian Institute of Technology Bombay

Preface

The following is the report comprising of the works done and experiences learnt during the summer internship (Project 1) in a NGO called 'Mobility India', Bangalore, which is a rehabilitation Centre for those who have difficulty in walking.

The duration of the internship was for one month, dated from 5th May 2014 to 6th June 2014.

Declaration

The content produced in this report represents my ideas in my own words and where other's ideas or words have been included adequate citations and references of the original sources have been made.

Trivikram A

136130013
I Year M. Des | Product Design
IDC, IIT- Bombay

Table Of Contents

Acknowledgement

I would like to thank Prof.Chakravarthy.B.K, H.O.D, IDC, IIT Bombay and Prof.Sandesh, Course Co-coordinator, Product Design, IDC, IIT Bombay, for permitting me to do the internship which was an enlightening experience.

I thank 'Mobility India' Bangalore for accepting my proposal to do my internship, especially Ms. Ritu Ghosh, Deputy Director, for the valuable support provided throughout the internship period and Mr. Saikot Ghosh Maulic, Assistant Director, for the constant guidance and mentoring.

I also thank all the staff, students and patients who were supportive during my internship period in Mobility India.

Introduction

The summer internship was an opportunity given to engage with an organization with an intention of gaining experience in an area relevant to Industrial design, in that regard a Non Government Organization (NGO) called 'Mobility India' was chosen where the one month long internship was done.

1.1 About Mobility India (MI) :

Mobility India is a registered society, established in 1994 in Bangalore, Karnataka with a Regional Resource Centre in Kolkata, West Bengal.

Mobility India is the first NGO school in India to receive accreditation from International Society of Prosthetics and Orthotics (ISPO).

Mobility India's objective is to provide support to ensure that people with disabilities have equal rights and a good quality of life, especially poor living in rural areas and urban slums.

In pursuit of this objective , MI set up its rehabilitation, research and training Centre in 2002. This is a disability-friendly building that houses MI's activities and provides rehabilitation services and various training programmes in rehabilitation, prosthetics and orthotics.

MI has a policy of employing people with disabilities in order to give them equal opportunities, hence most of the staff in Mobility India in all departments are people with major health issues (like Cancer patients) or other disabilities

Key Activities of Mobility India

1. Habilitation and Rehabilitation Services

Enabling people with disabilities to attain and maintain independence, and to achieve full inclusion and participation in all aspects of life.

Services provided :

- **Prosthetics and orthotics** – A workshop equipped with technology to provide quality assistive devices
- **Physiotherapy and Occupational Therapy** – focuses on children and adults achieving functional independence
- **Wheelchair** – assessing the needs and abilities of individuals requiring a wheelchairs

2. Human Resource Development in disability and rehabilitation

Develops appropriate rehabilitation personnel to provide wheelchair services, therapy prosthetics and orthotics in line with world health organization (WHO) and International Society of prosthetics and orthotics (ISPO) guidelines

3. Research and Development Centre

The Centre deals with product development which have better functionality and aesthetics using state of the art technology.

How I got my internship in Mobility India-

Initially the search was on for an NGO, Orphanage or Old age home which was open to taking in a product designer for internship. While doing on online search about the same, Mobility India was found, which looked apt for the internship, after corresponding with the director of the NGO through mails, the internship was confirmed.

Location of the Centre-

The NGO is located in the urban area of Bangalore, surrounded with lush greenery and is in close proximity to the historic Ragi Gudda temple.

Mobility India Rehabilitation Research & Training Center

1st & 1st 'A' Cross, J.P. Nagar, 2nd Phase,
Bangalore - 560 078.Karnataka, India.
Phone : +91-80-26492222 / 26597337 / 26491386 - Ext-9 (Reception)
Telefax : +91-80-26494444 Ext. - 110
Email : e-mail@mobility-india.org

What I wanted to accomplish

To acquire fresh experience, new knowledge, skill sets and newfangled world view

To learn and implement aspects of design in a field which is in need of designers

To come up with design solutions which does not stay on drawing board, but gets made and serves people in need

To practically implement the knowledge gained during first year of IDC

Time line

WEEK 1

- Got introduced to the structure of Mobility India
- Got introduced to various departments
- Searched for design opportunities
- Finalized areas of work
- Gave a presentation to guide about the various areas
- Started work on child development furniture(CDF)

WEEK 2

- Worked on child development furniture
- Made multiple concepts of CDF
- Started detailing CDF concept 1
- Started making prototype of concept 1
- Started detailing CDF concept 2
- Started making prototype for concept 2 of CDF
- Interaction with interns from UK

WEEK 3

- Testing of concept 1 prototype
- Met vendors for concept 2 of CDF
- Detailing of prototype for concept 2 of CDF
- Testing of Concept 2 prototype
- Started work on orthotic knee joint
- Refinement of concept 2 prototype

WEEK 4

- Started work on pelvic support
- Testing of pelvic support
- Documentation of Jaipur foot unit
- Exploring latest technology in prosthetics
- Interaction with service users
- Worked on splint designs for hemiplegic
- Presentation of works done in Mobility India

Design Methodology

Figure 1: Showing the design methodology followed during the internship.
Source: Author

Works done

The initial days of the internship were spent in understanding the system accurately after which the process of finding design opportunities was started, out of which the most appropriate and important opportunities were chosen and worked upon,

Following are the list of design opportunities found in Mobility India :

- One-hand driven wheel chair for amputees
- Design of child growth development aids
- Re-design of orthotic knee joints
- Enhanced aesthetic prosthetic leg for humans
- Leg divider for treadmills
- Pelvic support for gait training
- Hemiplegic hand splints
- Lamination room Layout design
- Wall mounted toilet commode
- Prosthetic leg for four legged animals

- Creating a mobile app for monitoring the patient improvement
- Design of a knee joint based on stress analysis

From the above list most important topics were chosen based on the number of patients needing a better solution, for instance number of patients in need of child growth development aid were close to 4000 per year in Mobility India, whereas patients in need of a wall mounted toilet commode are less than 500 per year, hence the design opportunity of child growth development aid was given more preference than the latter.

Supportive Seat : Concept 1

Figure 2 : Concept 1 of supportive seat for children with cerebral palsy
Rendered using keyshot
Source: Author

Children suffering from cerebral palsy, polio and other health ailments that lead to weak limbs need assistive devices to help them sit and stand upright in an ergonomic way which in a long term use leads to strengthening of the muscles and correction of the bad spine postures.

These devices are extensively used under following cases:

- Inability to sit independently, poor sitting balance and head control
- Child is not able to communicate properly because of poor position
- Child is not able to eat by himself because of poor sitting position
- Able to sit independently but is unable to arms
- Sits asymmetrically and is at a risk of developing postural deformities
- If the child is always lying on his/her back

There are existing models being manufactured in Mobility India, but the user has to buy one special chair for sitting and another standing frame, which leads to more cost and occupies more space, hence a new design had to be made which overcomes the problems.

Design Brief :

To create a new device that satisfies the following features :

a) The same device should be used for sitting and standing.

b) The device should have the following adjustability features :
    a) Foot rest adjustability
    b) Back rest adjustability
    c) Hip adjustability

c) The new device should use less material, when compared to the existing models.

d) The device should be aesthetically pleasing

e) The device must be strong and be able to withstand harsh usage

Parallel Product Study

[1]

[2]

[3]

[4]

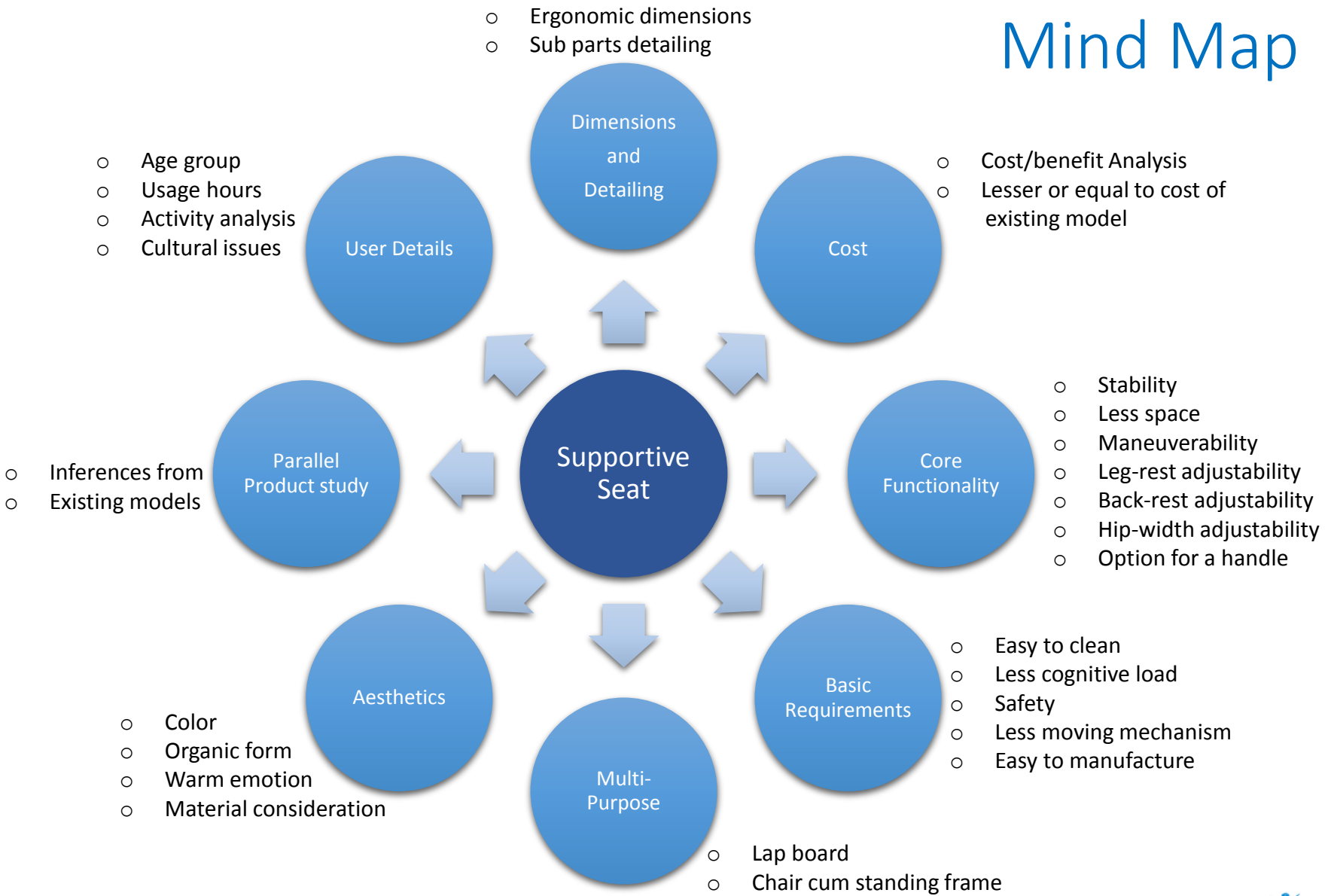
Picture 1 : Product study of other available supporting seats
Source: Various sources, Refer Citations

An online search was done in order to find out the different products which are used for assisting children with cerebral palsy

After the extensive research various inferences were made from the study, few of the **most prominent findings** have been listed below :

- Usage of moving parts must be avoided as it makes the device prone to frequent maintenance and increases the complexity of the design
- The design must be cost effective as most of the users belong to Below Poverty Line (BPL)
- The design must take into consideration that it does not make the user feel they are locked in a closed space
- There must be more ventilation as the user might be seated for long hours
- The design must be extremely stable, as children are bound to move awkwardly when trying to move around with the device

Mind Map


Supportive Seat
Dimensions and Detailing
Ergonomic dimensions
Sub parts detailing
User Details
Age group
Usage hours
Activity analysis
Cultural issues
Cost
Cost/benefit Analysis
Lesser or equal to cost of existing model
Parallel Product study
Inferences from
Existing models
Core Functionality
Stability
Less space
Maneuverability
Leg-rest adjustability
Back-rest adjustability
Hip-width adjustability
Option for a handle
Aesthetics
Color
Organic form
Warm emotion
Material consideration
Basic Requirements
Easy to clean
Less cognitive load
Safety
Less moving mechanism
Easy to manufacture
Multi-Purpose
Lap board
Chair cum standing frame

Ideations

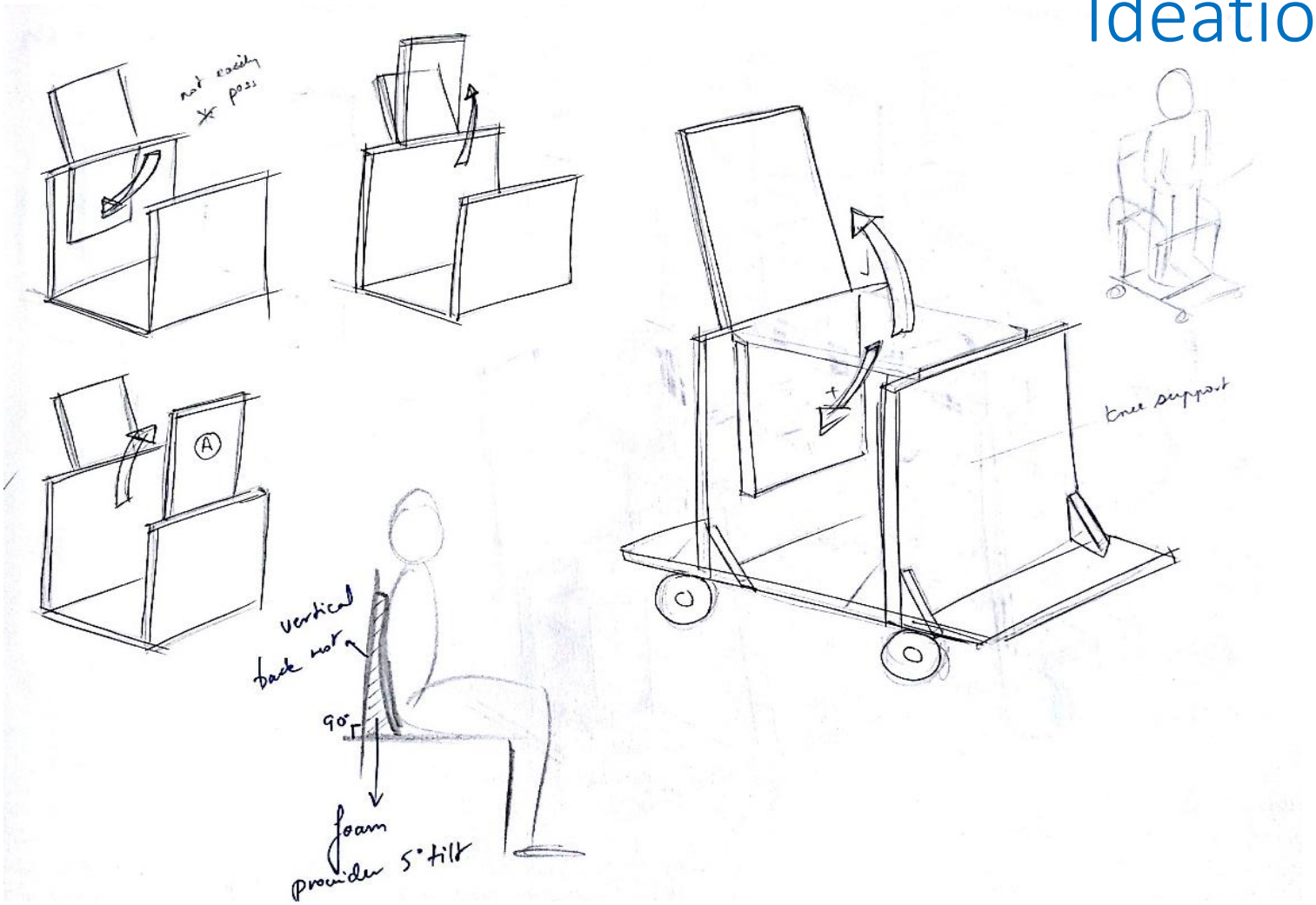


Figure 3 : Explorations of various seat folding options possible
Source: Author

Ideations

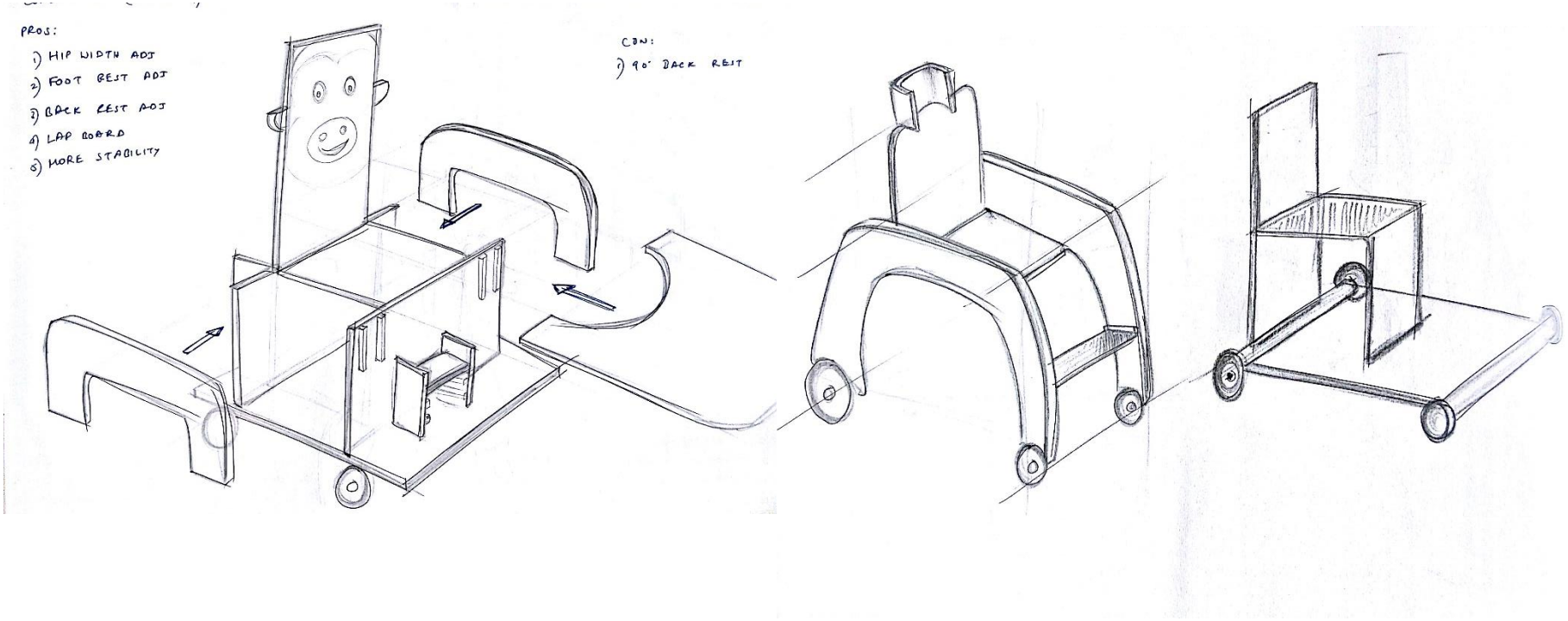


Figure 4 : Explorations of various adjustable components of the device
Source: Author

Ideations

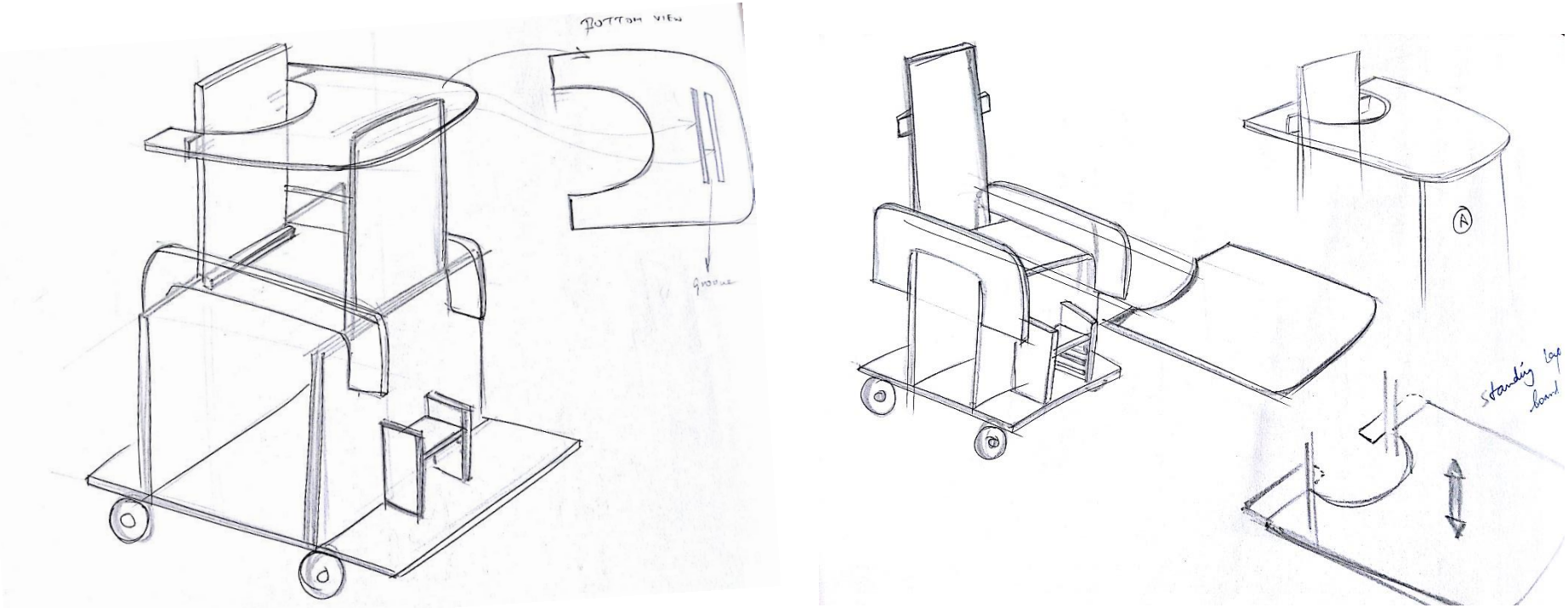


Figure 5 : Explorations of various adjustable components of the device
Source: Author

Prototype

Picture 2 : Prototype being made using plywood
Image Source: Author

In order to test the feasibility of the dimensions and detailing, a quick prototype was made using plywood. A lot of innovations and quick refinements were made during the prototyping which were missed out during prior stages.

Plywood was the material chosen to make the product as it was the most cost effective and strong choice for the given product.

After cutting the plywood according the dimensions, the pieces were frequently assembled to check the stability and correctness of the design. After the pieces were individually cut and assembled –every piece was coated with a layer of wood putty for enhancing the final appearance of the product and for extended durability of the paint. After allowing the putty to dry the surfaces were sanded using sand paper for getting a smooth surface finish.

Finally after the coating of putty was sufficiently dried two coats of paint were applied on the surfaces according to the prior decided color combinations of every part in the product.

To enhance the appeal of the final product a sticker of an animal eye was stuck on the side walls to give an appearance of a toy animal which would excite the child using the product.

Testing- refinements

Picture 3 : Prototype being tested on a user
Image Source: Author

In order to test the practical working of the product a volunteer was requested to use the prototype, by which we were able to test the core functionalities **desired for the product** such as :

- Stability
- Maneuverability
- Leg-rest adjustability
- Back-rest adjustability
- Hip-width adjustability
- Ease of usage of the handle
- Space occupied

The results were positive and the child who used the product was excited and happy. The child who tested the product was a current user of the old version of supportive seat and it was concluded that the new design was more appealing and compact.

Minor refinements had to be made with the vibrations of the back rest and a foam padding had to be given on the side panels as the child was found resting his head on the side panels frequently. The above said changes were taken care of before painting the product.

Final Model

[a]

[a]

[a]

Picture 4,4 : various painted parts of the final model, Picture 4: final model next to an existing supporting seat
Images Source: Author

Picture 4 : Final model on display in Mobility India
Image Source: Author

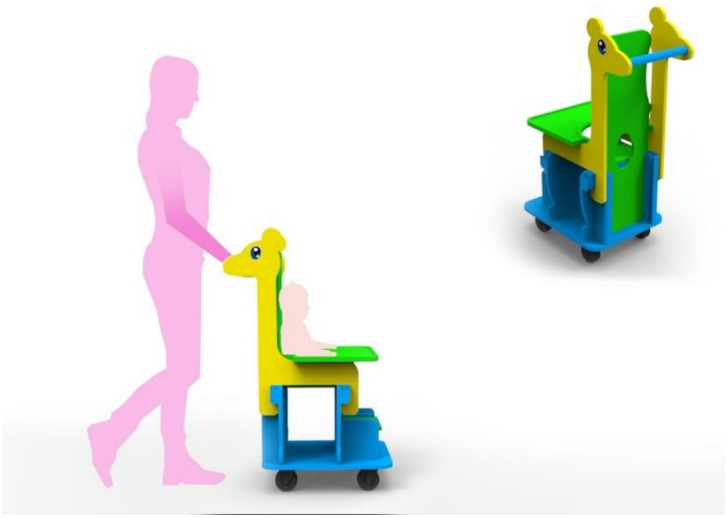


Figure. 6 shows the usage of the product as a seating and standing frame, when the seat is made vertical a space is provided for the child to stand in the pocket, when the seat is made to rest on the base it acts as a chair

Source: Author

Figure. 7 shows the maneuverability option of the product, the handle plays an important role of holding the side plates together.

Source: Author

Figure 8. shows the hip, backrest and footrest adjustability of the product

Source: Author

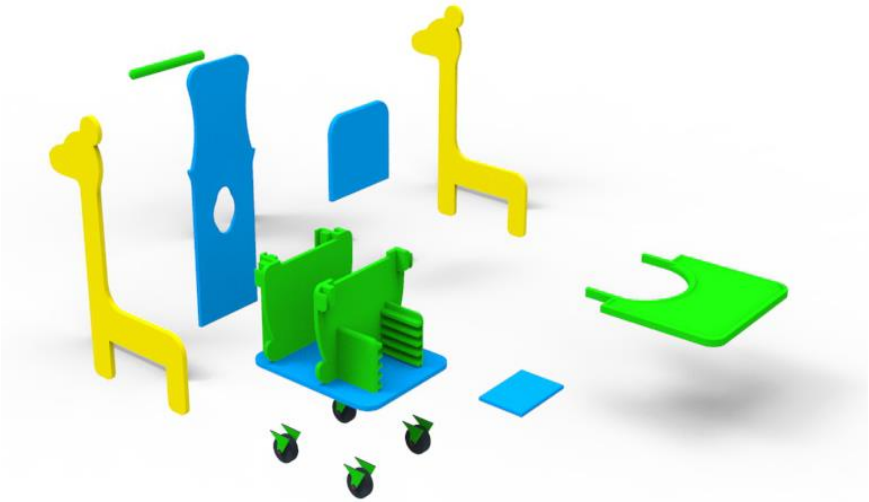


Figure 9. shows the exploded view of the product, a comparative study with the existing product showed that the new design saves 25% more material.

Source: Author

Supportive Seat : Concept 2

Figure 10 : Concept 2 of supportive seat design for children with cerebral palsy
Source: Author

After the interaction with the test users of the concept 1 supportive seat, it was found out that there was a need for a product targeted at the upper class users who wished to have **a more futuristic and stylish product**.

Hence another version of supportive seat concept was made with following additional features :

- Detachable parts for easy transport of the product
- Option for adjustable neck and knee support
- More robust and strong design

The new concept of supportive seat gave the freedom to the user to adjust the height of the add-ons at a wide range of levels, which gave an advantage of being extremely cost effective as one device could support a child from the age of 0-8 years, instead of buying a new product every time the child grew taller.

The proposed material for the device was Aluminum for its high strength and low weight properties, for the hip and seat leather was the choice of material.

Stability was one very important criteria for these types of products which involves children and moving around, hence considerations were made with respect to Centre of gravity of the product when a child uses them. Due to this reason the space and size of the wheels at the rear were made bigger than the ones at the front. Also the positioning of the middle bar was made such that even rugged use of the product doesn't compromise on the stability.

Parallel product study

[5]

[6]

[7]

[8]

Picture 4: Product study of other available supporting seats
Source: Various Sources, Refer Citations

A study was made on various products used for treating patients with cerebral palsy and other difficulties related to normal human maneuverability, the focus was more on the products which were not of the conventional chair designs but used other novel ideas to achieve the same results.

The **key findings** of the product study were :

- The importance of having appealing and futuristic designs without compromising on the core functionality aspects
- The increase in the usage of electronics leading to automation of the processes involved in making the patient sit and stand
- The in-corporation of multi-tasking features on to the product
- The need to come up with concepts which occupies very little space
- Usage of safety features like tracking the child movement using mobile apps and ringing alarms when the child has a fall or is facing some health problems

Ideations

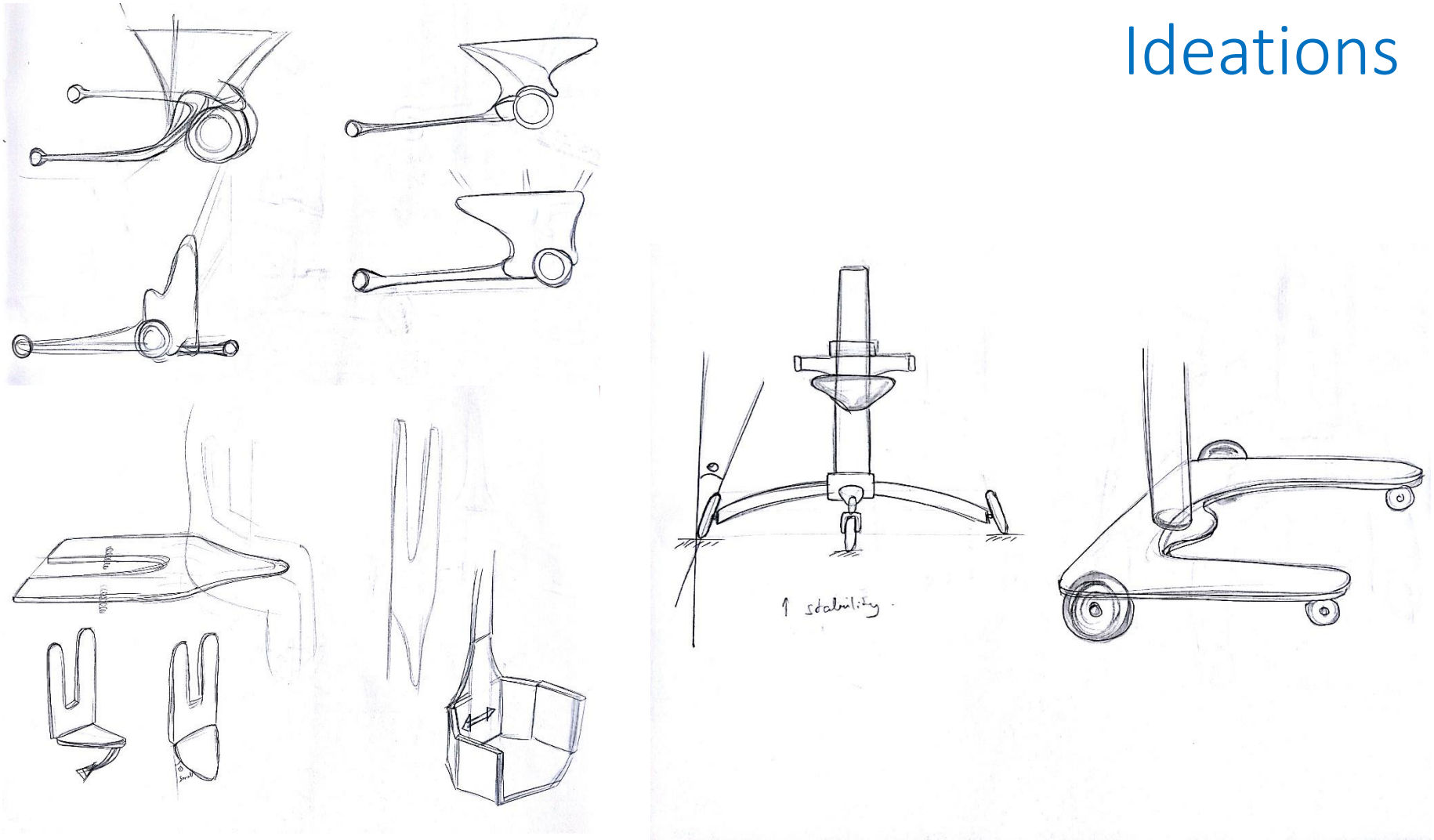


Figure 11: Ideations of various possible base structure for the device
Source: Author

Ideations

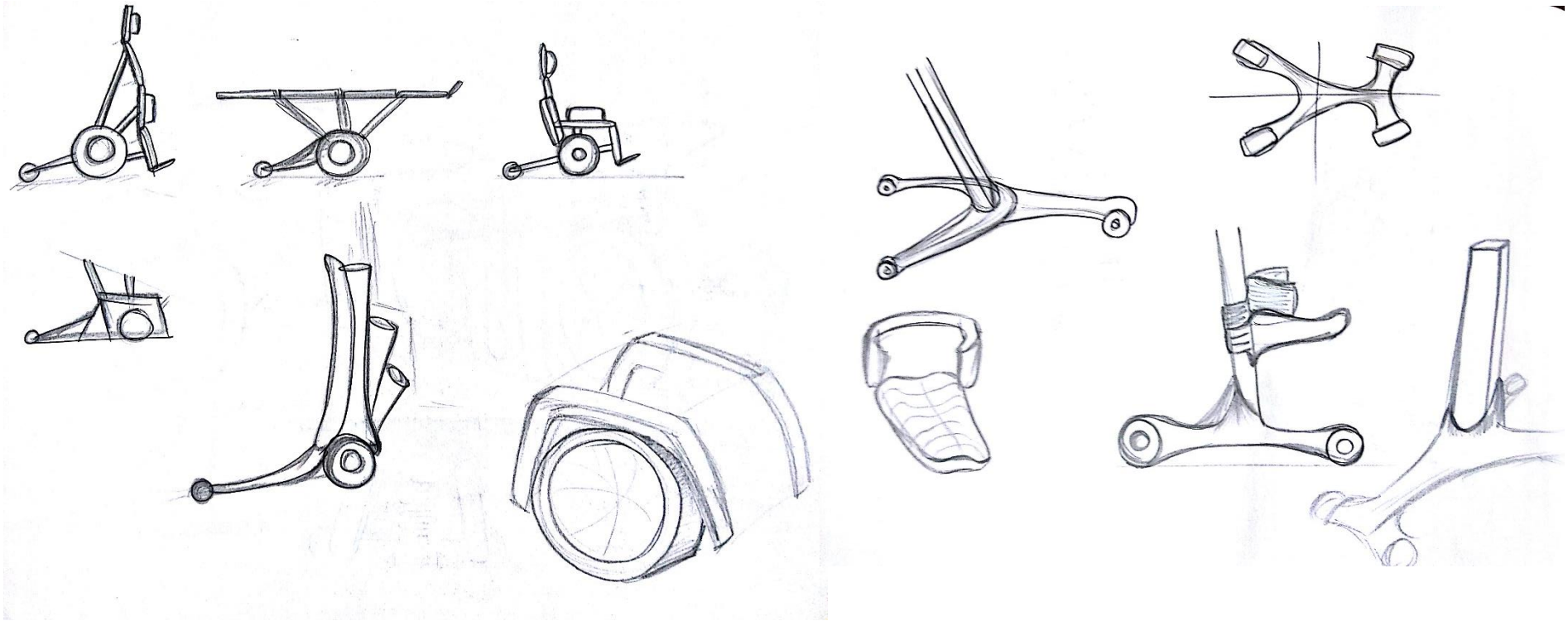


Figure 12: Ideations of various possible base structure for the device
Source: Author

Ideations

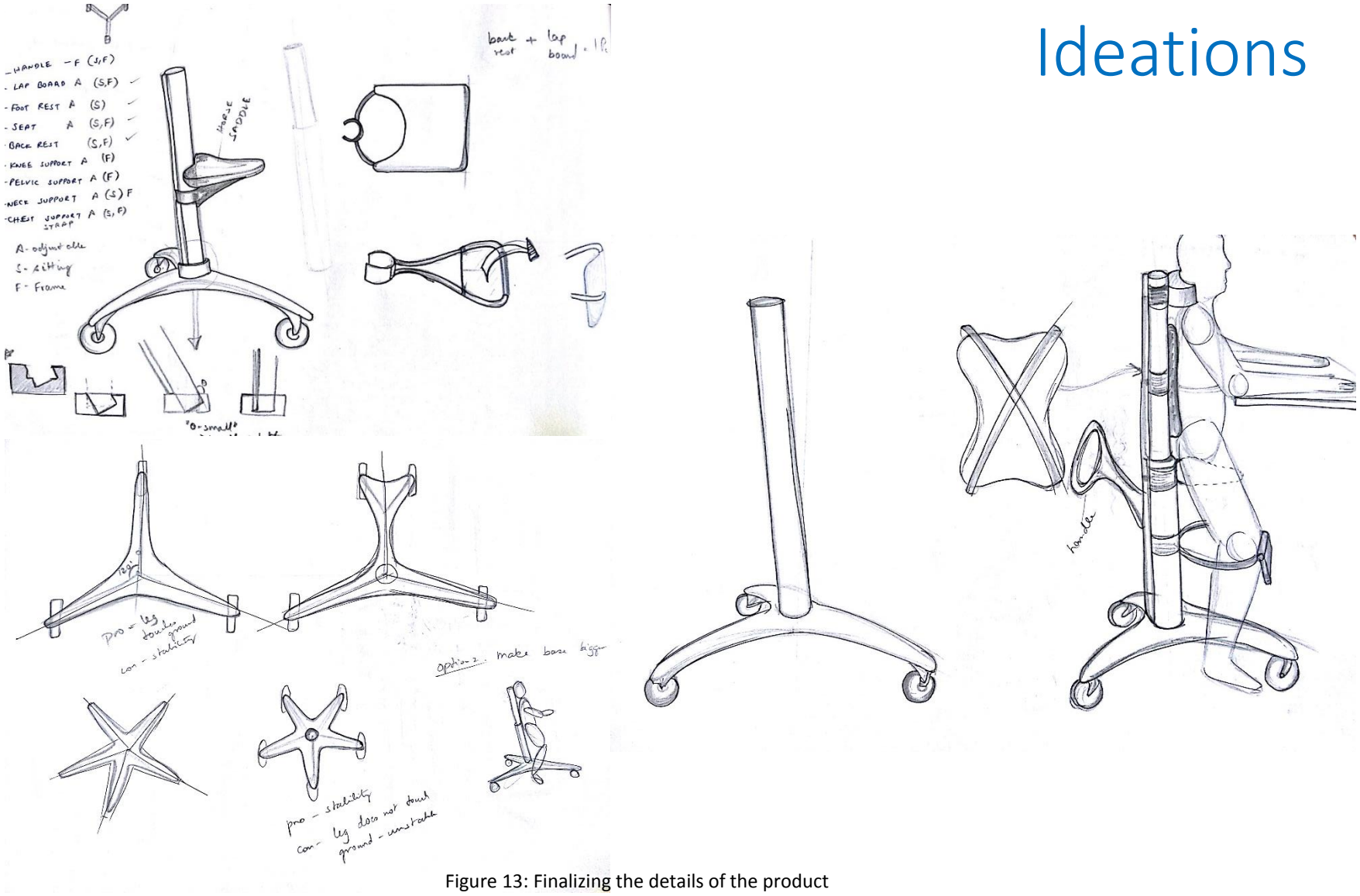


Figure 13: Finalizing the details of the product
Source: Author

Figure 14. Seat height adjustment of the device
Source: Author

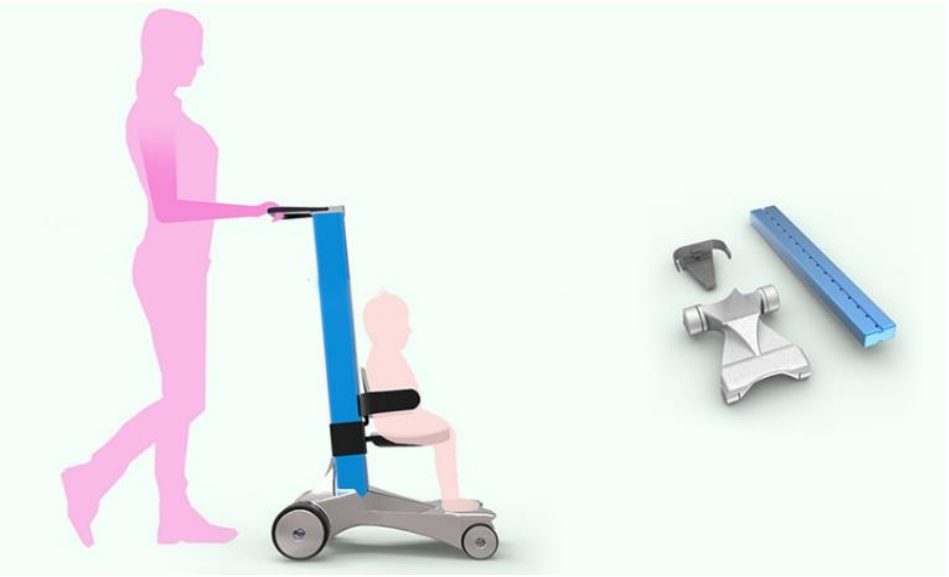


Figure 15. shows the product is easily movable with the child on it and can be easily detached into three parts which facilitates easy transportation of the device

Source: Author

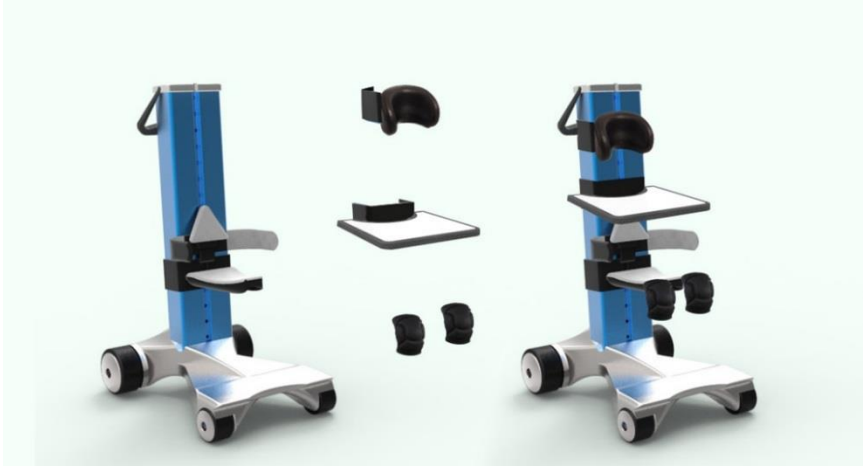


Figure 16. shows the multiple add-ons that are possible to be attached on to the device
Source : Author

Figure 17. shows the color variants possible with the device which enhances the futuristic appeal of the product
Source : Author

The picture alongside shows three such add-ons other than the seat, 1. Neck-head support, 2. Lap-Board, 3. Knee support.

Using a horse saddle seat while standing helps one solve scissor gait problems. It was observed that the needs of every child is different hence the child which needs a neck support may not need the knee support, thereby providing such add on features leads to possible customizations for the user.

In order the confirm the details of the product like the dimensions and stability , a quick model was made out of plywood as making a metal prototype and failing in it would be a costly error. After the testing it was found that the dimensions of the base had to be changed to adequately accommodate the legs of the patient.

Prototype




Picture 5 : Making of the Prototype and its testing with the user
Image Source : Author

Supportive seat: Concept 3

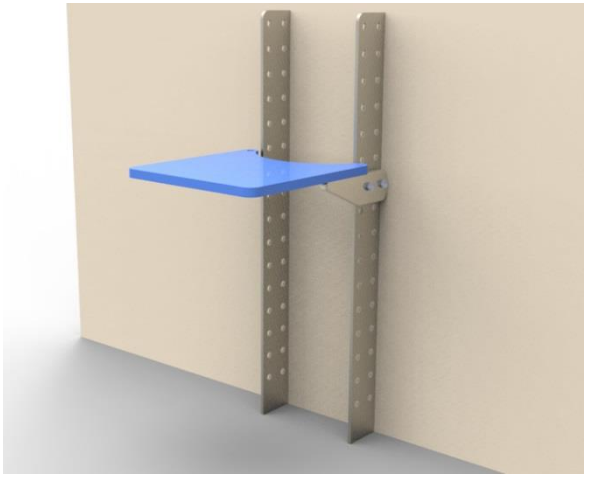


Figure 18. Shows concept 3 of fixed supportive seat
Sources : Author

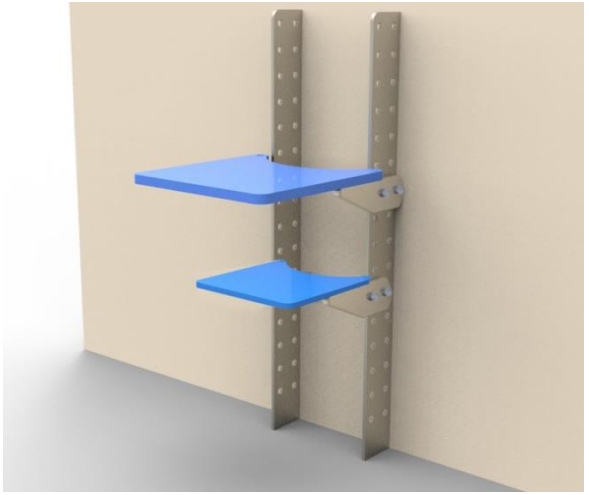


Figure 19. Shows supportive seat along with the lapboard
Sources : Author

The third variant of the supportive seat is the one shown in the picture alongside, it is a concept where the lapboard system is attached on to the wall permanently, such systems find their usage in homes were they have very little place to have the products like the ones mentioned previous which needs ample space to move around the product with the child.

The entire system involves very few parts making it an extremely cost effective solution for children with cerebral palsy living in places where the houses are small.

The system satisfies the core features expected of a supportive seat, such as, a lapboard along with straps for the knees holds the child firmly in standing position, when another board is kept at a different height it can be used as a seat.as shown in figure 19. after using the device it can be folded and kept on to the wall .

Since the supporting joints are of cantilever type, sufficient strength is obtained to hold the child firmly. The vertical beams need to be made of metal like mild steel or aluminum for strength and durability, whereas the boards can be made of plywood.

The details of the products working is clearly shown in the figure 20 to 21.

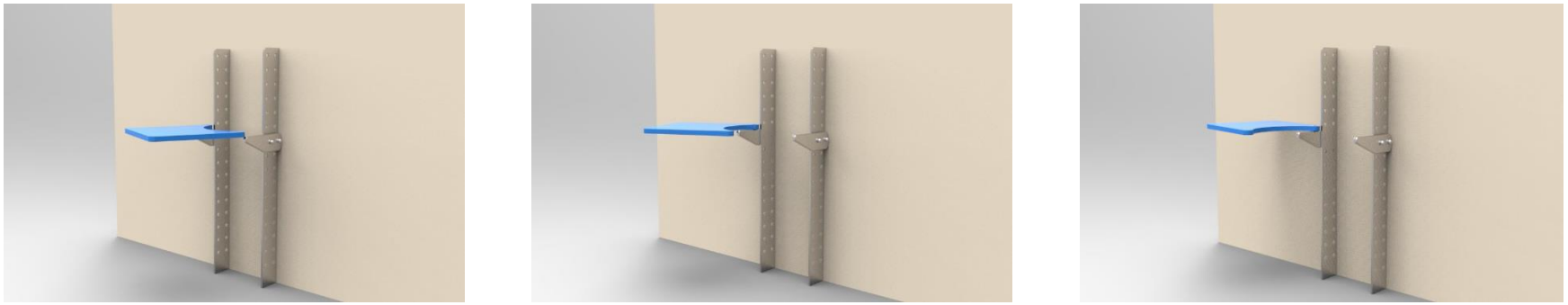


Figure 20. shows the lapboard, that slides across a fixed point
Sources : Author

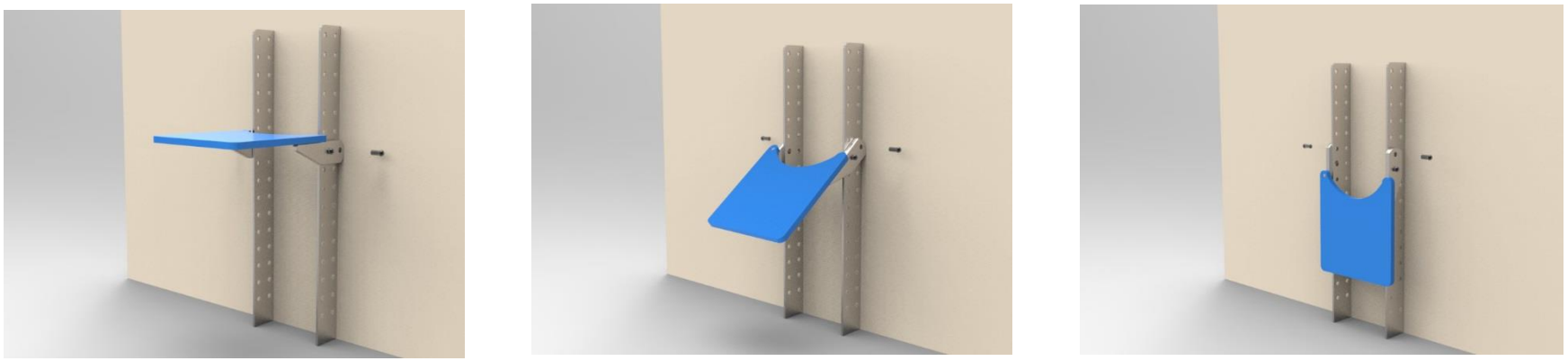


Figure 21. shows the closing of the lapboard, which is done by removing two bolts from the sides
Sources : Author

Ideations

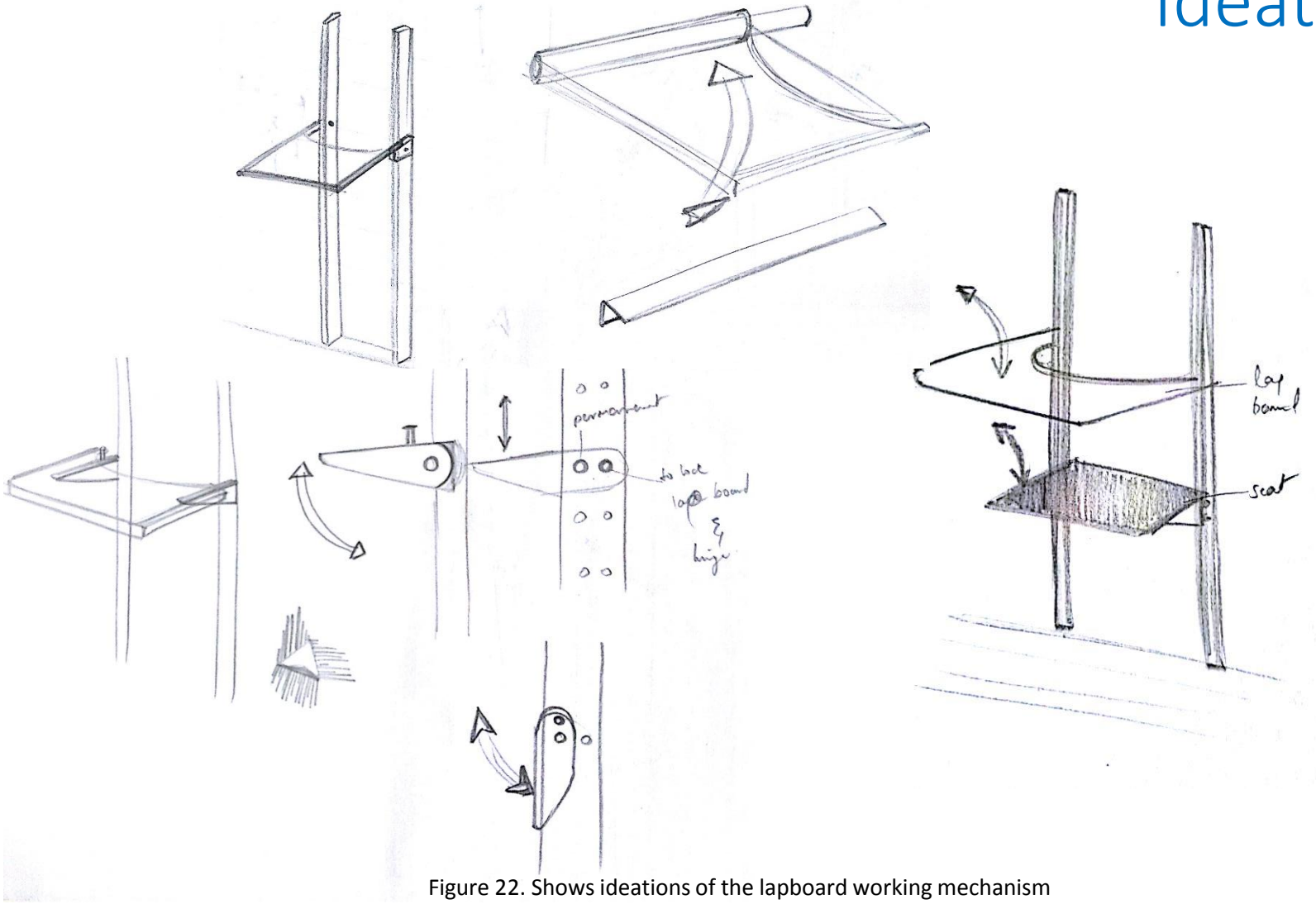


Figure 22. Shows ideations of the lapboard working mechanism
Sources : Author

Redesign Of Orthotic Knee Joint

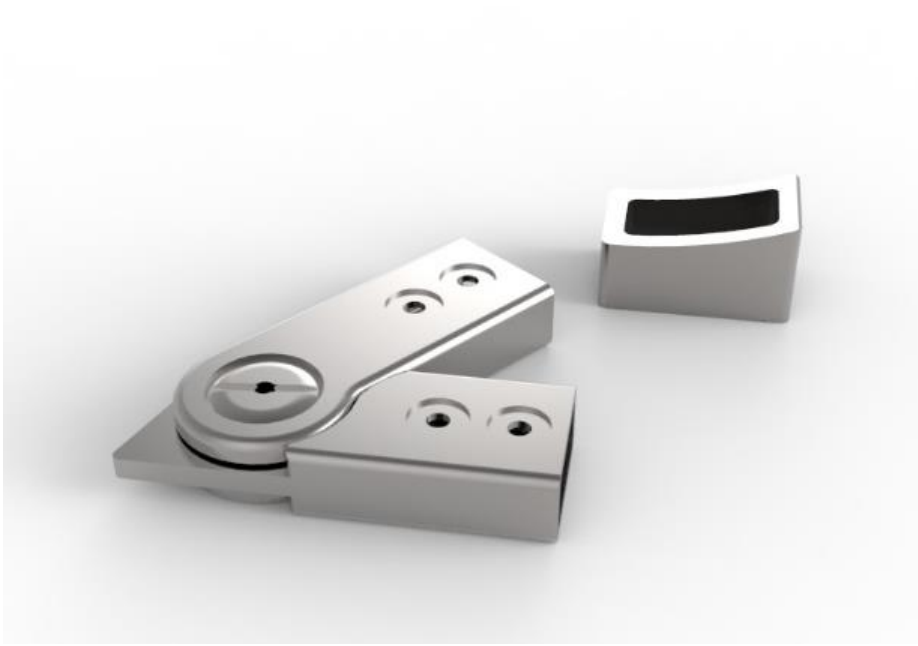


Figure 23. Metal orthotic knee joint rendered using keyshot
Sources : Author

Orthotics is an externally applied device used to modify the structural and functional characteristics of the neuromuscular and skeletal system.

Patients benefiting from an orthotics may have a condition such as spina bifida or cerebral palsy, or have experienced a spinal cord injury or stroke.

An orthotics may be used to:

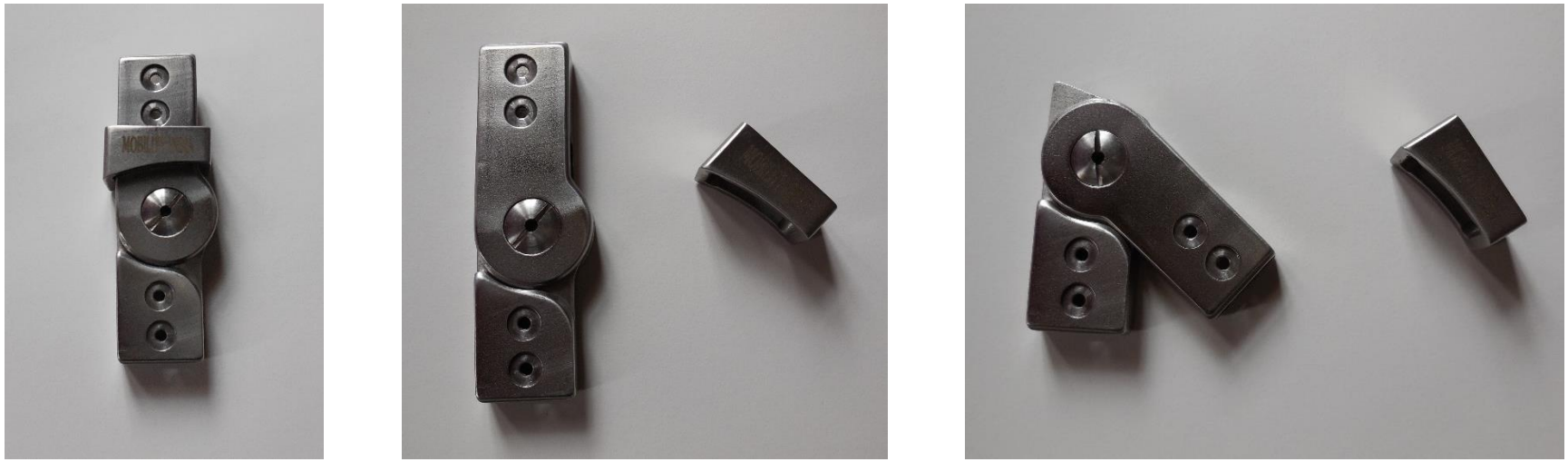
- Control, guide, limit and/or immobilize an extremity, joint or body segment for a particular reason
- To restrict movement in a given direction
- To assist movement generally
- To reduce weight bearing forces for a particular purpose
- To aid rehabilitation from fractures after the removal of a cast
- To otherwise correct the shape and/or function of the body, to provide easier movement capability or reduce pain

The orthotic knee joint does the above said functions for the leg, Helping people to walk without the need of wheel chairs or crutches. These knee joints are manufactured in Mobility India and sold at a subsidized cost, there are two variants in these knee joints depending on the size(child-2 and adult-3) and type of material used (Stainless steel – with and without coating)

Picture 6: Shows 130^{o} movement of orthotic knee joint
Sources : Author

The present design of the knee orthotic had a flexion angle of 110^{o} replicating the angle of natural knee bend, this is a standard followed in western countries, In Indian context due to the lifestyle differences we have when compared to the westerners there is a need to have a knee flexion angle of up to 130^{o}, for instance Indians have a habit of sitting on the floor with their legs folded on their laps, usage of Indian type of toilets; for these kinds of usages there needs to be a flexion of 130^{o} which facilitates the Indian mobility habits. .

There had to be changes done in the structure of the knee joint in order to achieve a greater flexion angle, this was done using 3D software like solid works, the drawings obtained from the software will be later used for modifying the metal dyes in order to produce a new upgraded knee joint with increased flexion angle.



Picture 7.. Shows the working mechanism of orthotic knee joint
Sources : Author

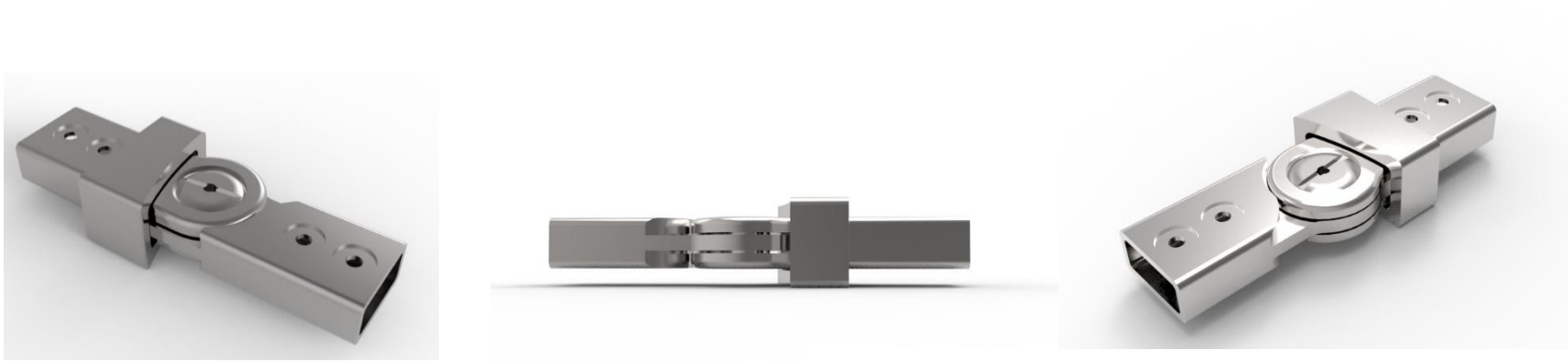


Figure 24. Shows different views of orthotic knee joint rendered in keyshot
Sources : Author

Design of Pelvic support

Picture 8. Shows the pelvic support being used
Sources : Author

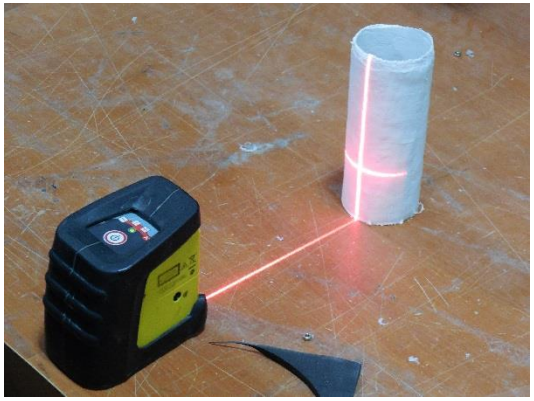
A pelvic support is an assistive device that helps people with lower body paralysis to be able to walk during Gait training. The pelvic support basically holds the hip in a steady position avoiding excessive wobbling and moves along with the patient over the metal pipes.

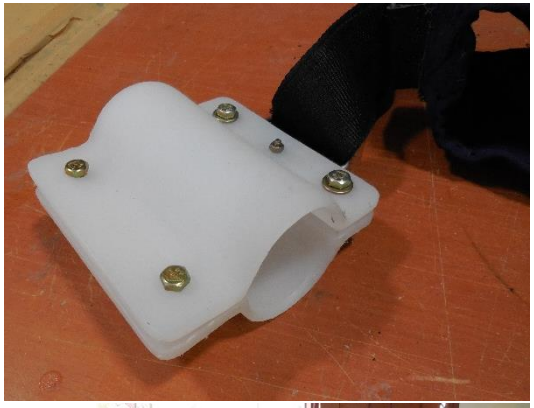
While analyzing the bio-mechanics of people with lower body paralysis it was noticed that instead of another person holding the hip of the patient an assistive aid could be used, which could reduce the patients dependence on others for walking.

During Gait training the patients are thought to walk with the newly fitted orthotics or prosthetics, assistance is provided usually by a physio-therapist and physical devices like metal pipes, the patients are made to walk for many days with the support of these pipes and get used to their new gait.

Using a pelvic support would help the patient gain confidence and train alone till the strength gets built up in the pelvic area. After getting sufficient muscle strength the usage of pelvic support can be slowly discarded.

The pelvic support has Velcro straps making it adjustable to various sizes of patient's hips also the circumference of the movable cylinder joints on the metal pipes can be adjusted depending on the level of friction required over the metal pipe while walking.





Picture 9. Shows the pelvic support being made and tested
Sources : Author

Ideations

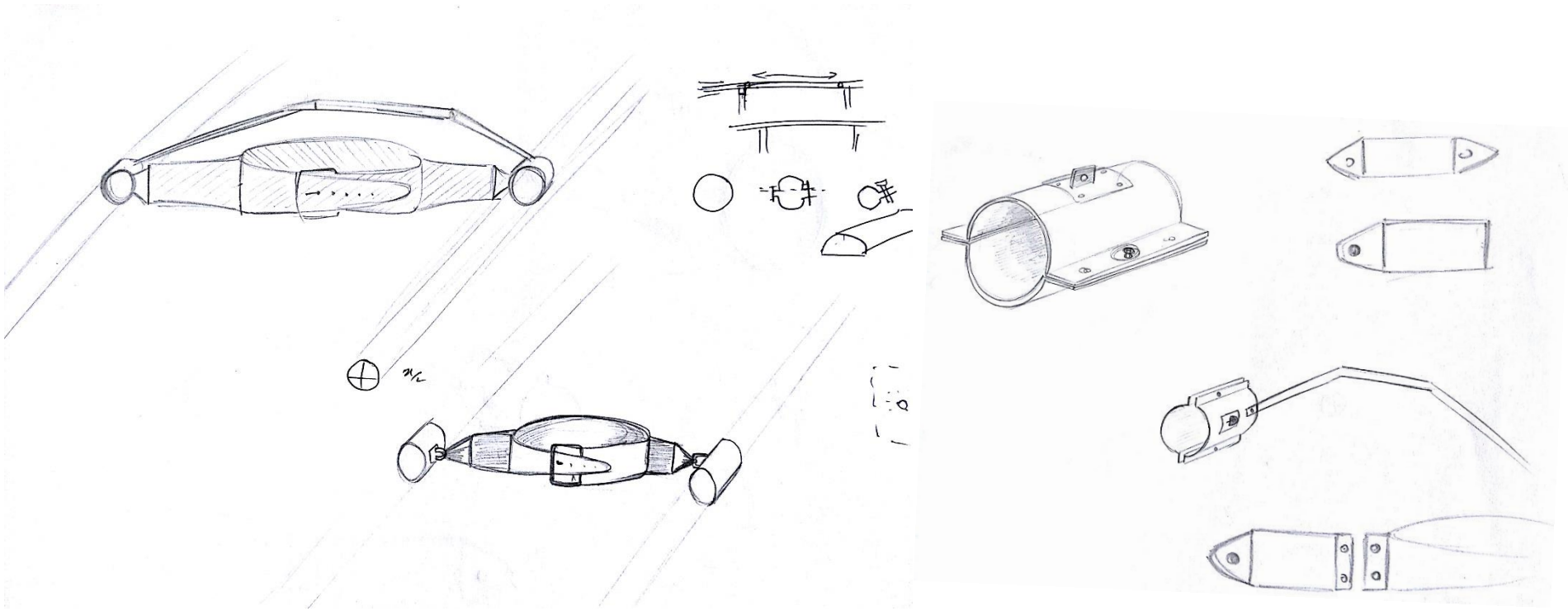


Figure 25. Ideations of the pelvic support details
Sources : Author

Design Of Splints For Hemiplegics

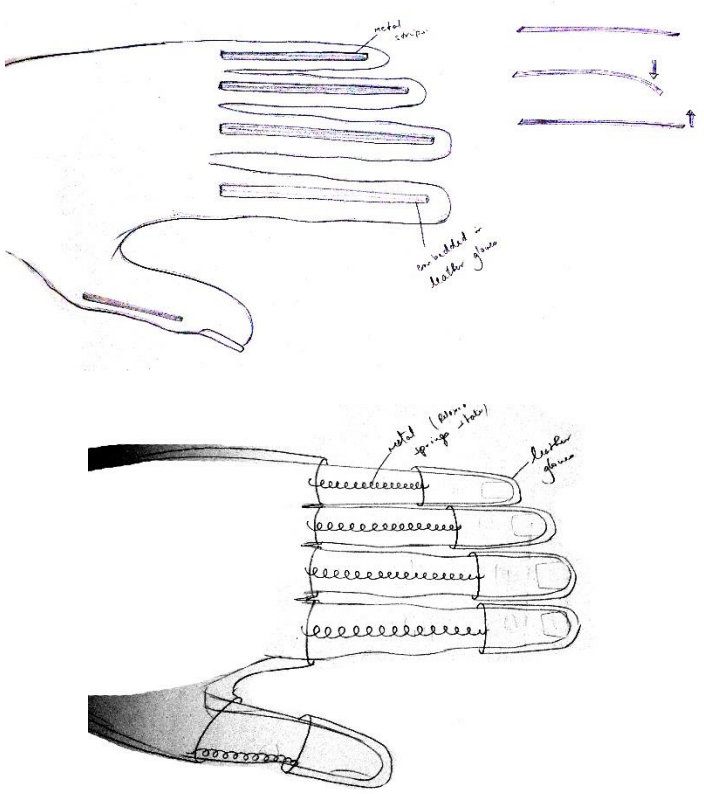


Figure 26. Shows two concepts of splints for the hemiplegics
Sources : Author

During the exploration of design opportunities in the NGO, one important need that was found in terms of the number of users needing the design solution was the design of new types of splints for hemiplegics. Nearly half of the patients coming to Mobility India
Were hemiplegics and the biggest issue with the treatment given to the hemiplegics is the difficulty in regaining full mobility in the affected limbs.

From the observations made during the time spent with hemiplegic patients it was found that unless an externally forced movement is given to the patient the affected muscle's condition becomes more spastic and rigid leading to permanent loss of movement and normalcy in the affected body parts, in that regard few new designs of splints were ideated which with application of external force leads to natural movement of the affected limb (in this case –hand), on prolonged usage of such splints it has been proven that the patient has been able to regain normalcy to a large extent.

The principle of splint design for the hand was that the force required to do the closing motion had to be applied by the patient, where as the opening motion of the fingers would be automatically taken care of by the splint.

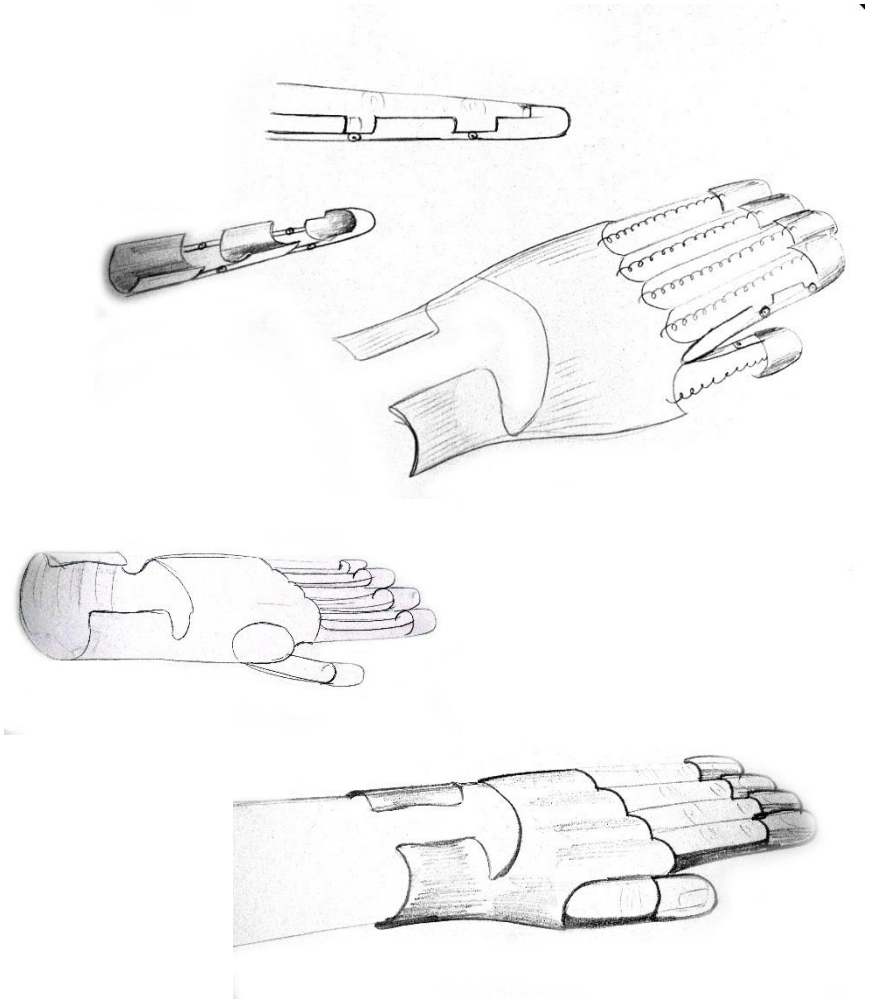


Figure 27. Shows two concepts of splints for the hemiplegics
Sources : Author

Concept 1 shows the case where a metallic strip with high flexibility and retracting capacity is embedded in the splint such that by default the splint always stays in a open hand position unless tried to close by the user.

Concept 2 and 3 makes use of springs, such that the function of the earlier used metal strips is taken care of by the springs, the reason for using the springs is that they have the option of adjusting the tension by increasing and decreasing the length of the spring.

Concept 4 does not use either springs or metal strips, but a flexible plastic like polypropylene is used which provides the necessary flexibility for the finger movement.

Ideations

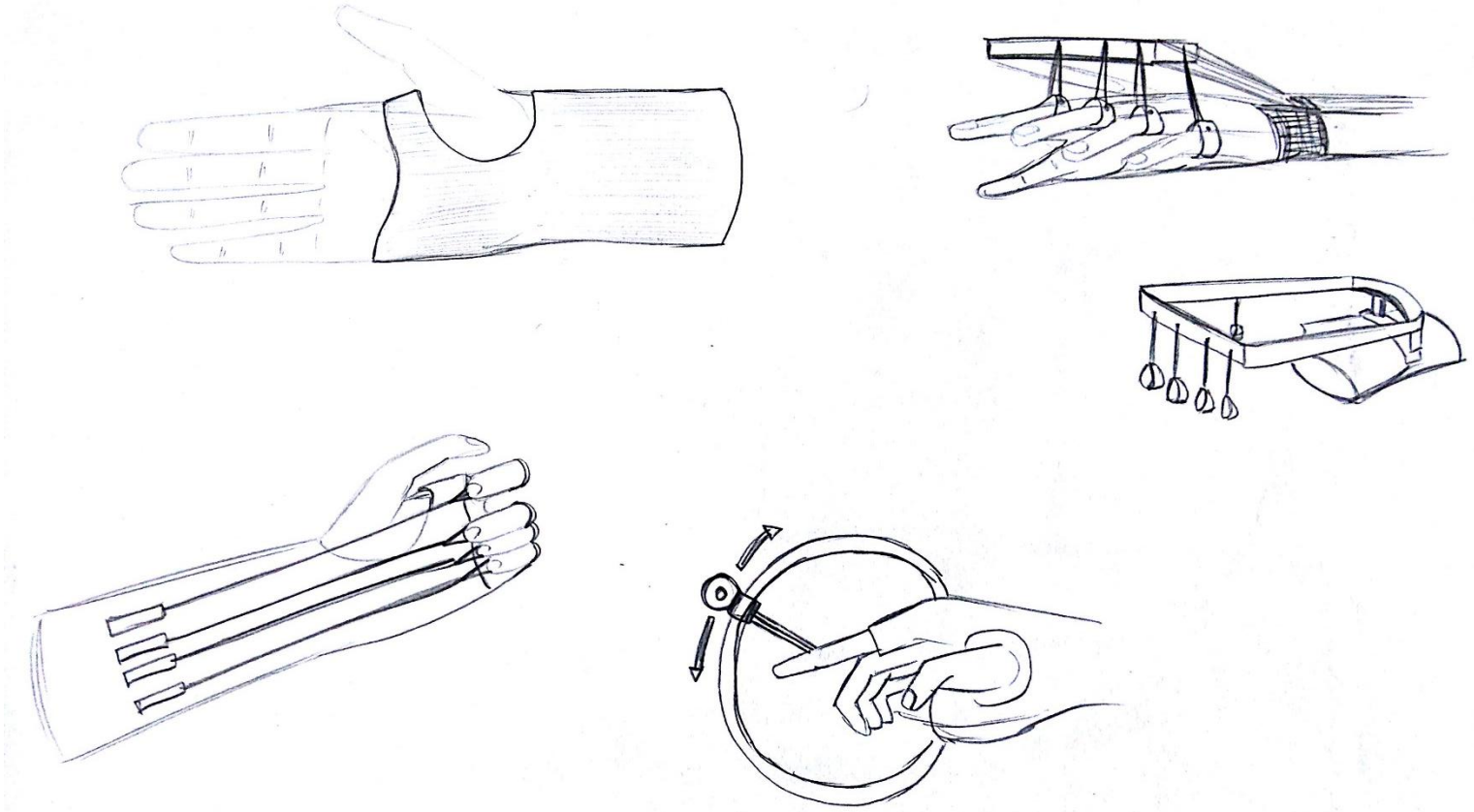


Figure 28. Shows various other splints for the hemiplegics
Source : Therapy handbook

Importance of Technology

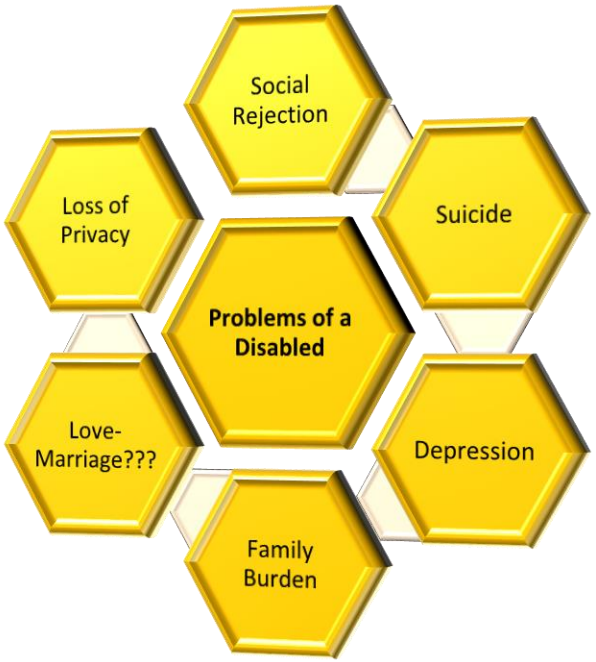


Figure 29. Problems faced by a disabled
Sources : Author

According to a census by the ministry of home affairs, government of India, there are 21 million disabled people in India who are in need of medical assistance which could up to some extent bring back the normal life to the person in need.

When one sees the life of a disabled from a close point of view it's marginally possible to understand the problems faced by them, for instance :

- They are subjected to social rejection and treated as an outcast
- They are prone to suicidal tendencies
- They become additional burden to their family
- They lose their personal space and privacy
- They undergo a lot of depression and mental stress
- They are usually devoid of marriage and face many other societal problems

One very important tool which makes bringing back the normalcy to the disabled a possibility at a faster pace is the advancements happening in technology, last decade alone has seen an outburst of new inventions and improvements in existing aids like automated exo-skeletons, usage of electronics in human like prosthetics, bio-compatible materials, 3d printable orthotics etc.

Picture 10. Shows a functional cosmetic finger
Sources :
http://www.genesisprostheticarts.com/casesexamples/futuretechnologies.html

On many occasions it has been noticed that the patients who are provided with a fully functional prosthetic, with a working efficiency that resembles close to the natural human body part are still not fully satisfied and happy with the product, and prefer to avoid its usage or cover it externally to make the device unseen.

The reason for this behavior is that the patients are just not happy with getting back what they have lost in the form of a working machine but they want some thing more to it**, they expect to have the element of reality**, they expect to have a device which looks exactly like the lost human part.

This is were the importance of cosmetics comes into picture, the knowledge of materials that resemble the human part plays a very big role of adding a layer of reality on to the product.

This scenario is fast catching up in India, where more and more assistive devices are being customized and made to look as original as possible, whereas is foreign countries like Germany and U.K it's found that the trend is towards having products which are more aesthetic with elements of style and futurism into them, that makes the bionic look more like a sci-fi robot.

Exo-skeletons

Picture 11. Shows various exo-skeleton concepts being developed
Sources :
http://www.cyberdyne.jp/english/products/LowerLimb_medical.html
http://www.tuvie.com/search/robot

A **powered exoskeleton**, also known as **powered armor**, **exoframe**, or **exosuit**, is a mobile machine consisting primarily of an outer framework (akin to an insect's exoskeleton) worn by a person, and powered by a system of motors or hydraulics that delivers at least part of the energy for limb movement.

Mobility India does not limit itself to providing its patients with the age old hand made orthotics and prosthetics, depending on the complexity on the patient's problems and the financial status ,efforts are taken to provide them with latest kind of machines available, most of the exo-skeletons are still on research level, studies are conducted with research institutes like NIMHANS(National Institute of Mental Health and Neurological Sciences).

Exoskeletons could be applied in the area of rehabilitation of stroke or Spinal cord injury patients. Such exoskeletons are sometimes also called Step Rehabilitation Robots. An exo-skeleton could reduce the number of therapists needed by allowing even the most impaired patient to be trained by one therapist, whereas several are currently needed. Also training could be more uniform, easier to analyze retrospectively and can be specifically customized for each patient. At this time there are several projects designing training aids for rehabilitation centers

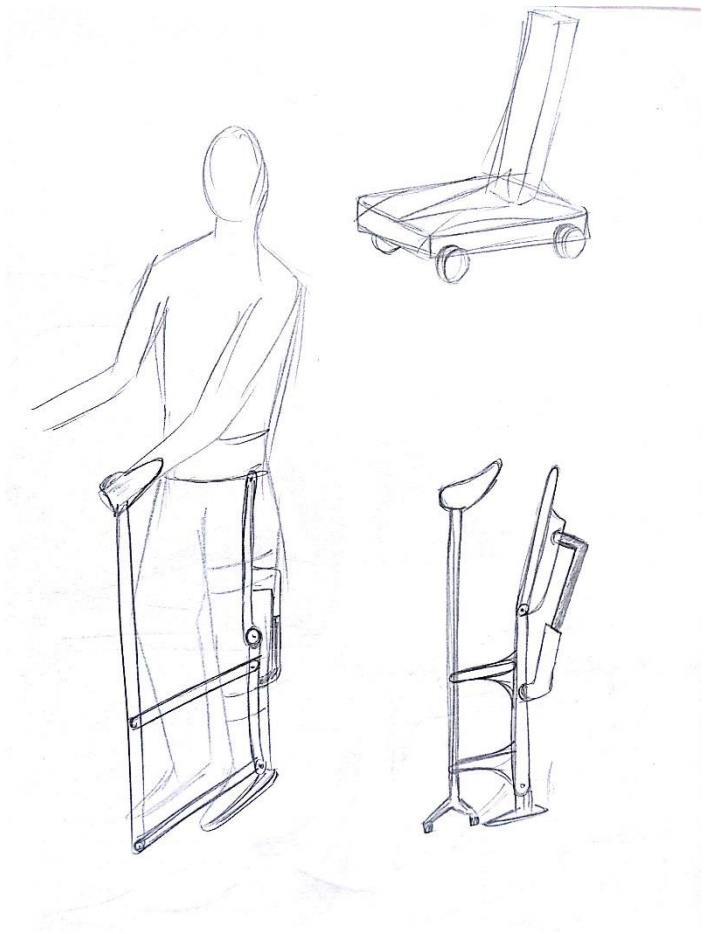


Figure 29. Shows a concept of human powered exo-skeleton
Source : Author

- ReWalk: ReWalk features powered hip and knee motion to enable those with lower limb disabilities, including paraplegia as a result of spinal cord injury (SCI), to perform self-initiated standing, walking, and stair ascending/ descending.
- Sarcos/Raytheon XOS Exoskeleton arms/legs. For use in the military, weighs 68 kg (150 lb) and allows the wearer to lift 90 kg (200 lb) with little or no effort. Recently, the XOS 2 was unveiled, which featured more fluid movement, increase in power output and decrease in power consumption.
- Ekso Bionics/Lockheed Martin HULC (Human Universal Load Carrier) legs, the primary competitor to Sarcos/Raytheon. Weighs 24 kg (53 lb)and allows the user to carry up to 91 kg (201 lb) on a backpack attached to the exoskeleton independent of the user.[A modified version of HULC is also in development for medical use, to help patients walk.
- Ekso Bionics eLEGS: a hydraulically powered exoskeleton system allowing paraplegics to stand and walk with crutches or a walker
- Cyberdyne's HAL 5 arms/legs. The first cyborg-type wearable robot allows the wearer to lift 10 times as much as they normally could.HAL 5 is currently in use in Japanese hospitals, and was given global safety certification in 2013.
- Honda Exoskeleton Legs. Weighs 6.5 kg (14 lb) and features a seat for the wearer.
- M.I.T. Media Lab's Biomechatronics Group legs. Weighs 11.7 kg (26 lb)
- Parker Hannifin Indego Exoskeleton: an electrically powered system for paraplegics to walk with crutches.

Ideations

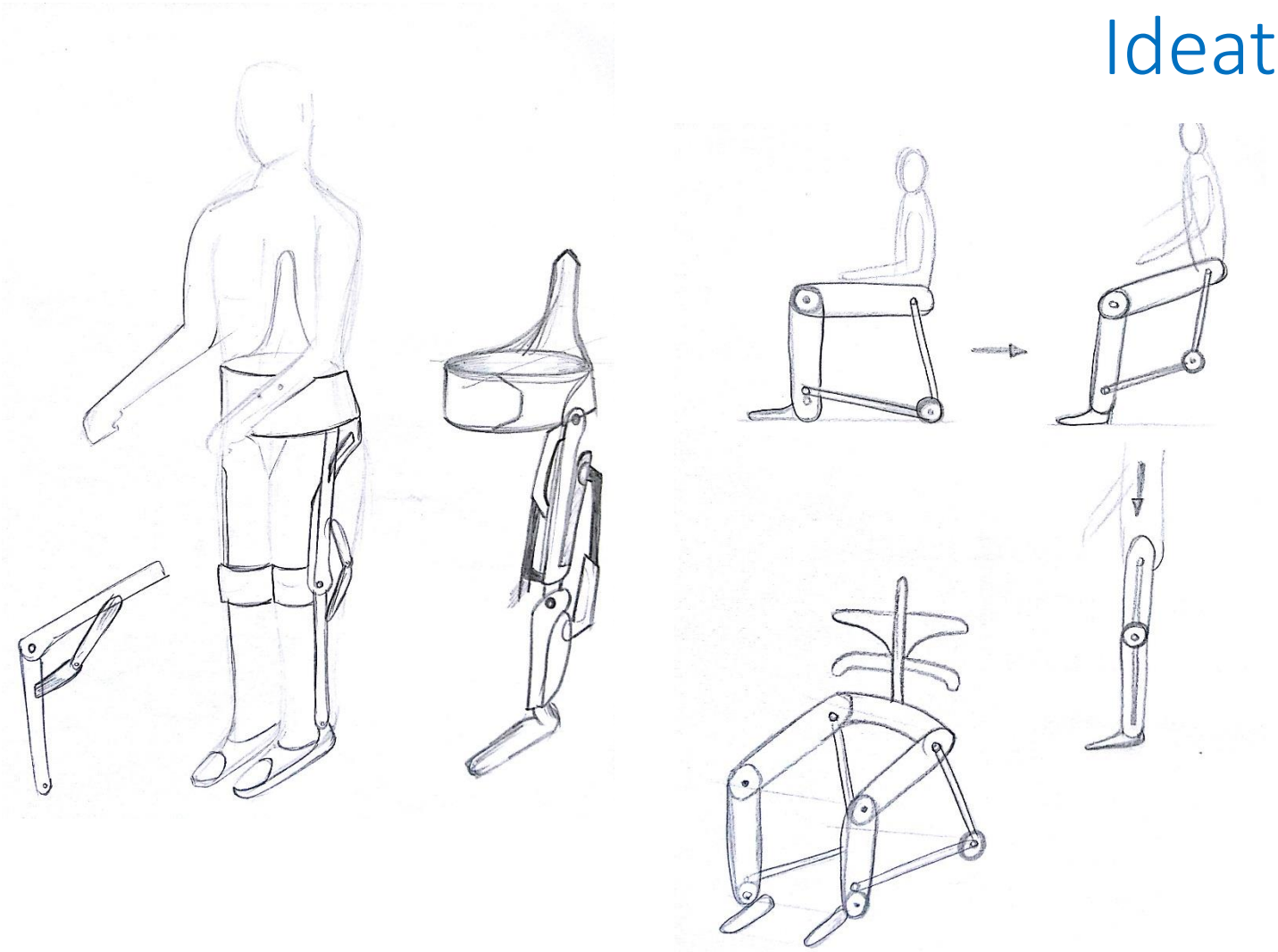


Figure 30. Shows concepts of human powered exo-skeleton
Source : Author

3D Printing

Picture 12. Shows two variants of 3D printing machines
Source : http://www.extremetech.com/extreme/159218-3d-printing-pioneer-stratasys-looks-to-the-future-and-buys-makerbot-thingiverse

Picture 13. Shows 3D printed skull pieces
Source : http://www.dutchnews.nl/news/archives/2014/03/dutch_hospital_gives_patient_n.php

3D printing is any of various processes of making a three-dimensional object from a 3D model or other electronic data source primarily through *additive processes* in which successive layers of material are laid down under computer control

As of 2012, 3D bio-printing technology has been studied by biotechnology firms and academia for possible use in tissue engineering applications in which organs and body parts are built using inkjet techniques. In this process, layers of living cells are deposited onto a gel medium or sugar matrix and slowly built up to form three-dimensional structures including vascular systems. The first production system for 3D tissue printing was delivered in 2009, based on NovoGen bio printing technology. Several terms have been used to refer to this field of research: organ printing, bio-printing, body part printing, and computer-aided tissue engineering, among others.

3D printing has been used to print patient specific implant and device for medical use. Successful operations include a titanium pelvis implanted into a British patient, titanium lower jaw transplanted to a Dutch patient, and a plastic tracheal splint for an American infant. The hearing aid and dental industries are expected to be the biggest area of future development using the custom 3D printing technology. In March 2014, surgeons in Swansea used 3D printed parts to rebuild the face of a motorcyclist who had been seriously injured in a road accident

Aesthetics

Picture 14. Shows a new design of crutches
Source : http://www.tuvie.com/prosthetic-leg-design-by-joanna-hawley/

Picture 15. Shows new designs of leg prosthetics
Source : http://www.tuvie.com/tag-heuer-prosthetic-leg-by-koo-ho-shin/

In the designing of health care aids the most important aspect of consideration is the core functionality and safety. Once those two primary criterion are met, other areas like aesthetics are looked into which enhances the usage experience and adds marketability value to the product.

Solicitation of aesthetics onto the prosthetic or orthotic device makes the user feel encouraged to display the device openly when in public places, a trend which is quickly catching up in western countries, which would reduce the social stigma disabled people suffer .

Ideations

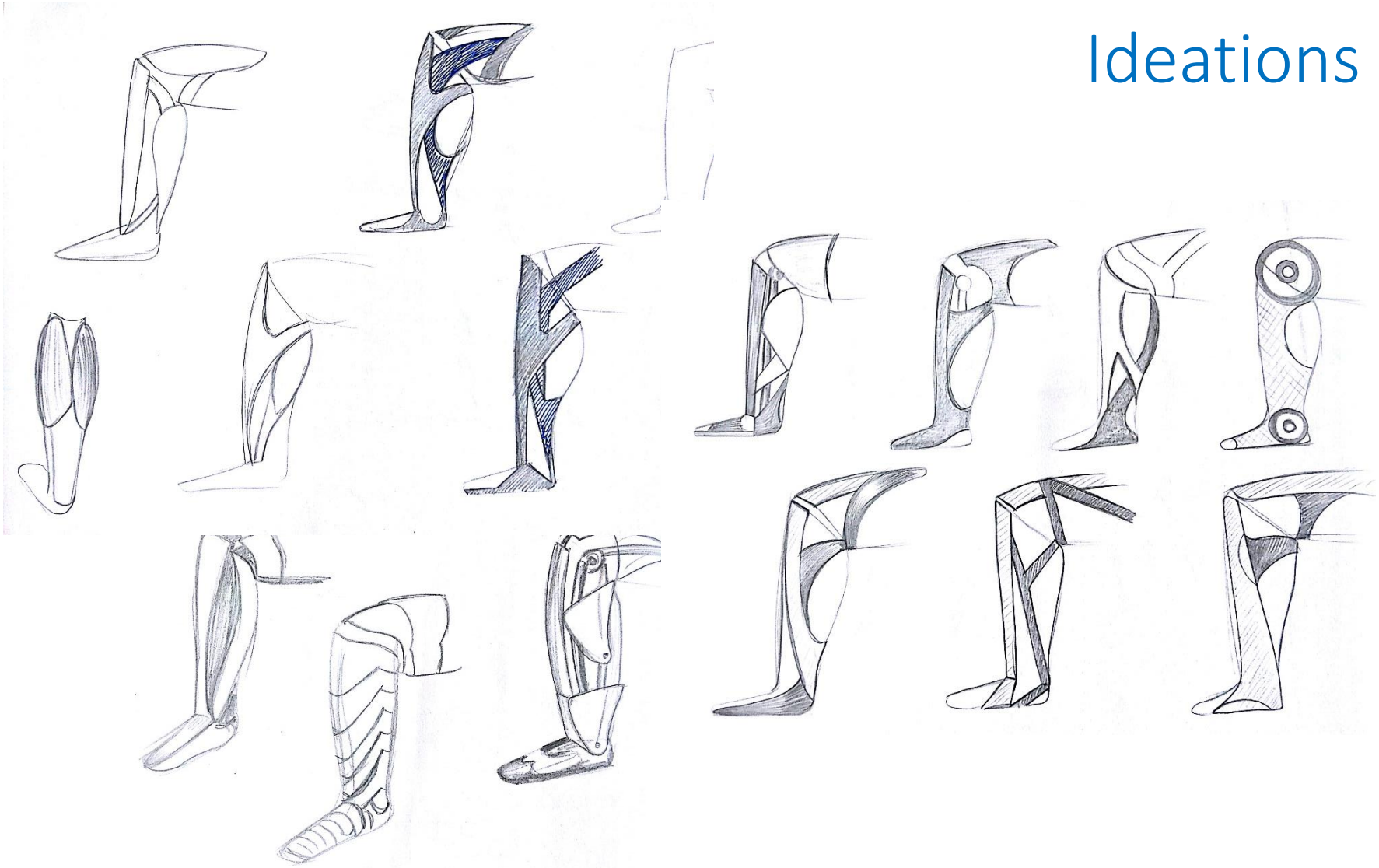


Figure 31. Shows ideations of external body designs to be used on the existing leg prosthetics
Source : Author

Bio-Compatibility

Picture 16. Shows an eye lens, an example of bio-compatible material

Source: http://www.plastics-themag.com/applications/life-saving-plastics/engineered-plastics-keep-the-body-moving

A **biocompatible material** is a synthetic or natural material used to replace part of a living system or to function in intimate contact with living tissue.

The products made in Mobility India like the most common orthotics and prosthetics are usually in contact with the human body for long durations, hence the material used for making the products needs to be bio-compatible to avoid causing any kind of allergies, infections or other skin problems.

Hence an exposure was got regarding the kind of materials which are bio-compatible and safe to be used on the patients skin.

The following is the list of bio-compatible materials that are widely used:

- Polyvinylchloride or PVC — Blood tubing, blood bags
- Polyethersulfone or PES — Single and multi-lumen tubing, catheters
- Polytetrafluoroethylene or PTFE — Catheter linings, single and multi-lumen tubing, synthetic blood vessels, endoscopes, surgical sutures, reconstructive surgery, soft tissue regeneration patches
- Polyethylene (PE-UHMW or PE-LD & HD) — Surgical cables, artificial tendons and orthopedic sutures, tubing

Bio-compatibility

Polyurethane or PU — Breathable wound dressings

Polyetherimide, PEI — Reusable and sterilizable applications, surgical skin staplers

Polycarbonate or PC — Medical instruments and containers with glasslike transparency, check valves and tubing connectors

Polysulfone or PS — Surgical and medical devices, clamps, artificial heart components, heart valves

Polyetheretherketone or PEEK — Dentistry products, rigid tubing

Polypropylene or PP — Heart valve structures

Jaipur Foot Manufacturing Unit

Picture 18. Jaipur Foot Manufacturing Unit in Mobility India
Source : Author

The Jaipur Foot, also known as the Jaipur Leg, is a rubber-based prosthetic leg for people with below-knee amputations. Although inferior in many ways to the composite carbon fiber variants, its variable applicability and cost efficiency make it an acceptable choice for prosthesis. Ram Chander Sharma designed and developed it in 1968.

Designed in and named after Jaipur, India, the prosthetic leg was designed to be inexpensive, water-resistant, and quick to fit and manufacture. The Jaipur Foot is made of polyurethane, which at the time was the new material used in the production of the prostheses. On similar lines Jaipur foot is manufactured in Mobility India without compromising on the quality of the original Jaipur foot.

The manufacturing unit in Mobility India employs 8 women, all 8 of them are disabled, the reason for employing disabled women in the unit, is because of the vision of the director who believes **only a disabled person understands the difficulties faced by another disabled person and could make a product with empathy and concern**.

The employees are well trained and equipped who make about 40 pieces of Jaipur foot per day and export it to various parts of India and other developing countries.

Picture 19. A finished piece of Jaipur foot
Source : Author

Picture 20. Cross sectional view of Jaipur foot
Source : Author

Materials Involved In the making of Jaipur foot :

- Vulcanizing cement
- Black cushion compound (BCC)
- Red cushion compound (RCC)
- Black tread compound (BTC)
- Tyre cord (Nylon)
- Rubber adhesive solution
- Toluene solution
- Wooden Planck
- Aluminum sheets
- Vaseline or any other vegetable oils

Selection and storage of materials

Uncured rubber is soft and becomes brittle in very cold weather and tears in heat, hence they are stored in a cool and dry place of temp (22-24 ^{o}C)

Wood block is cut and pasted with foam sheet

Blocks are segregated according to various sizes

Another coating of resin layer is added

The foam and resin are glued together and dried

The foot is removed the from dye and extra pieces of rubber are cut

PROCESS INVOLVED IN MAKING JAIPUR FOOT

Small pieces of skin color vulcanizing rubber is added

The dye is then heated up to 120^{o}C

The dye is closed and pressed at a high pressure

Block is placed inside a metal dye

Entire block is covered with multiple layers of rubber

Figure 32. Shows the brief process involved in manufacturing of Jaipur foot
Source : Author

Key learnings

- Understood the **importance of a designer** in an organization and the impact a designer has in enhancing the functionality, aesthetics and thereby the marketability of the product
- Importance of flawless detailing in the product
- The **need to be updated** with the latest technology and know basics of many trades
- Importance of 3-D rendering software
- The scope **healthcare industry** has in India
- Importance of effective presentation skills
- The ability to **connect emotionally** with people
- Finally, the importance of acknowledging the fact that we are **fortunate to have a healthy body**.

People met during Internship

Ms. Ritu Ghosh
Deputy Director-Training,
Mobility India
ritu@mobility-india.org
+91-9611323004

Mr. Saikot Ghosh Moulic
Assistant Director – P.O.T,
Partner Support, Mobility India
soikat@mobility-india.org
+91-9845348801

Mr. Rajnish
Head, RnD
Mobility India
rajnish@mobility-india.org

Mr. Hemanth Kumar
Head, Administrative Block
Mobility India
e-mail@mobility-india.org

Mr.Kamraj
Staff
Mobility India

Mr. Raju.S
Head physiotherapist
Mobility India
therapy@mobility-india.org
+91-9886828682

Mr. Sudhakar
Head physiotherapist
Mobility India
therapy@mobility-india.org
+91-9620056879

Mr. Riyaaz
Physiotherapist
Mobility India
therapy@mobility-india.org
+91-9964926420

Ms. Sujatha Srinivasan
Professor,IITM
Sujsree@iitm.ac.in

Mr.Rajdeep
Staff
Mobility India

Dr. Raja Lakshmi
Dentist, Wheel chair user
awsumraj@gmail.com
+91-9844137499

Mr.Faazal
Vendor – Metal works
Mobility India

Mr.Shyaam.P
Student
Mobility India

Mr. Alex Fawcett
Intern from UK
alex859@Hotmail.co.uk

Ms. Sarah
Intern from UK

Mrs.Nandini
Service user-hemiplegic
Mobility India

Mr.Abhinav
Service user-Cerebral Palsy
Mobility India

Mr.Srikant
Service user-Paralysis
Mobility India

Ms.Pallavi
Service user-Amputee
Mobility India

Mr.Ganesh
Carpenter
Mobility India

Mr.Govinda
Service user-Amputee
Mobility India

Mr.Siva Kumar
Carpenter
Mobility India

Mr.Anand
Student,M.Tech
Machine design
Anand.10pwr2@gmail.com

Mr.Ivan
Student
Mobility India

Mr.Alex
Student
Mobility India

Mr.Manikandan
Staff
Mobility India

Mr.Arun Kumar
Service user-Amputee
Mobility India

Mr.Waseem
Student
Mobility India

Mr.Poornima
Librarian
Mobility India

Mr.Mamta
Staff
Mobility India

Conclusion

I wanted to take this summer internship opportunity to spend my time in a place where I could serve people directly, I found a rehab Centre for those who cant walk as the perfect place to do so. I was very happy to **apply the aspects/methodology of design** I learnt in IDC to make solutions which made people's life a little better.

During the internship I got to learn about new materials, manufacturing process and latest technological advancements, along with skills like interacting with disabled people who usually not very open about discussing their health condition, effective presentation and marketability of product are the other things I learnt. I am sure that all these skills set that I have gained during my internship will be helpful for my future projects.

There were a lot of heart wrenching experiences which I came across during my internship which have **transformed me as a person** and has given me a whole new world view.

I would **strongly recommend** the future batches to take up their internship in such areas which directly uplifts the lives of people and experience the happiness one gets in doing so.

Bibliography

- Robotic mobilization device
  <http://www.core77.com/blog/medical/default.asp?p=2> as seen on 08.06.2014
- Prosthetic arm
  <http://www.popsci.com/category/tags/prosthetics> as seen on 10.06.2014
- Huggle chair
  <http://www.dlf-data.org.uk/product.php?product_id=0106976> as seen on 15.06.2014
- Creative chair designs
  <http://psdsociety.blogspot.in/2011/07/20-creative-chair-concept-designs.html> as seen on 17.06.2014
- 3D printing
  <http://www.ft.com/cms/s/0/6dc11070-d763-11e1-a378-00144feabdc0.html >. as seen on 08.06.2014
- Basics of 3D printing
  <http://mashable.com/2014/05/08/what-is-3d-printing/.> as seen on 08.06.2014
- Wheeel chair design
  <http://mobilitybasics.ca/wheelchairs/manualcomp> as seen on 08.06.2014
- One hand operated wheelchair concepts
  <https://www.google.co.in/search?q=one+hand+operated+wheelchair&es_sm=122&tbm=isch&tbo=u&source=univ&sa=X&ei=8wlpU6-_IcWRuATDh4CIBw&ved=0CEwQsAQ&biw=1366&bih=600> as seen on 08.06.2014

Bibliography

- Cerebral Palsy
  <http://www.cpaustralia.com.au/index.php/site/learningcentre>as seen on 08.06.2014
- Prosthetics leg
  <https://grabcad.com/library/prosthetic-limb-lower-leg>as seen on 08.06.2014
- Ottoblock Prosthetics
  <http://www.ottobock.com/cps/rde/xchg/ob_com_en/hs.xsl/5494.html> as seen on 29.06.2014
- Spinal Injury
  <http://www.mayoclinic.org/diseases-conditions/spinal-cord-injury/basics/coping-support/con-20023837> as seen on 24.06.2014
- Prosthetics
  <http://www.popsci.com/category/tags/prosthetics> as seen on 19.06.2014
- Exoskeletons
  <http://www.tuvie.com/rewalk-exoskeleton-helps-paraplegics-walk/> as seen on 25.06.2014
- Bionic suit
  <http://www.tuvie.com/ekso-bionic-suit-helps-people-with-lower-extreme-paralysis-to-stand-and-walk/> as seen on 09.06.2014
- Exo skeleton
  <http://eksobionics.com/ekso> as seen on 09.06.2014
- Ottoblock prosthetics
  <http://www.ottobock.com/cps/rde/xchg/ob_com_en/hs.xsl/3459.html?id=teaser1#teaser1> as seen on 20.06.2014

Citations

[1] Source : www.easystand.com as on 08.06.2014

[2] Source : http://www.livingmadeeasy.org.uk/children/tilt_in_space-armchairs-2854-p/

[3] Source : http://www.mobilityproducts.org/products/Pictures/

[4] Source : www.jeevanphysiotherapyequipments.com/c-p-chair.html

[5] Source : www.especialneeds.com/shop-by-diagnosis-cerebral-palsy.html

[6] Source : www.tuvie.com/cplegia-conceptual-cerebral-palsy-walking--unit-for-children/

[7] Source : http://seniortechdaily.com/new-technologies-help-people-remain-mobile-and-independent/

[8] Source : http://www.tasmanianwheelchairs.com/