

DESIGN PROJECT III

Geometry Kit for Visually Impaired Kids

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176130002 (2017-19)

Industrial Design
IDC School of Design

Guide - Prof. Purba Joshi



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Declaration

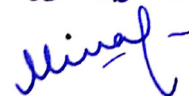
I declare that this written report represents my own idea in my own words, and where others, ideas or words have been included, I have mentioned the original source. I also declare that I have adhered to all principles of academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea, data, facts or source in my submission.

I understood that any violation of the above will be cause for disciplinary action by the Institute and can also cause penal action from the source from which proper permission has not been taken, or improperly cited.

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Sign - 

Approval sheet

This Industrial Design project report entitled "GEOMETRY KIT FOR VISUALLY IMPAIRED KIDS ", by Minal Agarwal is approved in partial fulfilment of the requirement for Master of Design degree in Industrial Design.

Project Guide - Prof. Purba Joshi



Chair Person -



Internal Examiner -



External examiner -



Date -

Acknowledgment

The successful completion of this project is result of concerned efforts, guidance and inspiration from many people. I feel indebted to my guide, Prof. Purba Joshi, for being a driving force throughout and helping me with her experience. Appreciation to all other PD faculty members for their valuable suggestions and feedbacks on the project. I am also thankful to my friends and colleagues, for their support and valuable inputs.

I would also like to appreciate the efforts of organisations such NAB(National Association for Blind), XRCVC (Xavier's Resource Center for the Visually Challenged) and National Institute for the Empowerment of persons with Visual Disabilities (Divyangjan) to provide a better life to the blind and visually impaired people. The kind support of Neha Trivedi Ma'am from XRCVC led to the completion of this project. The project would not have been possible without the cooperation I received from the people working at these institutes. I am thankful to the Visually impaired people who volunteered to provided feedback.

At last but not least I am grateful to my family, who have supported me throughout.

Name - Minal Agarwal

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Sign-



Abstract

The number of blind people in India is 12 million out of which 26% are children. These children will be making major contributions to the society in coming years.

Due to slow cognitive development and the inability to see, visually impaired kids face a lot of difficulty in education and learning. There are requirements for special methods and tools to make them understand various educational concepts. It was observed that due to the lack of certain resources, visually impaired kids are deprived of learning more visually inclined (diagram or picture) topics

Geometry is taught in upper primary schools to sighted students, however due to the complexity and unavailability of proper instruments it is not taught in majority of Blind Schools in India.

This design project dedicates itself to help the visually impaired children to learn basic geometry and be able to construct simple geometric diagrams.

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1. Introduction

A brief insight into the project, the process and methods followed

The project began with an intention to design a product to aid visually impaired people in general. With that objective in mind, many Institutions for Blind were visited to understand the need and requirements of blind people. It helped in realizing that the needs of different age groups of blind people varied drastically. These interactions also helped me broaden my horizons about the scope of this project. However, after visiting a blind school in Dehradun and meeting the teachers and students there, the focus of the project was restricted to designing for school students.

This was lead by further research, a few more Special schools were visited in Mumbai, which helped in listing different design directions like Products that aid Vocational Training, multiple Educational products and products that are required in Skill Training . Out of which '*design for aiding school students to understand and draw geometric diagrams*' was short-listed.

Existing geometry kits were collected from different sources and their usage was thoroughly understood and analysed. This data was simultaneously used to generate ideas to solve the problems in more creative ways, these were further tested and tried to form more refined concepts that would aid the blind students to draw tactile geometric diagrams.

Constructive feedback was collected while testing the prototypes, which helped in developing the final product.

Methodology

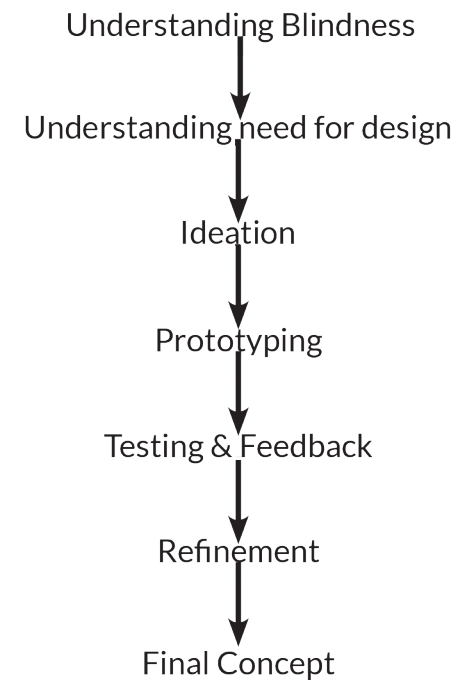


Fig 1. The diagram depicts the method followed to led to final design.

2. Secondary Data Collection

Understanding Blindness, Causes and effects

Visual Impairment

Visual impairment, also known as vision impairment or vision loss, is a decreased ability to see to a degree that causes problems not fixable by usual means, such as glasses.

Visual impairment is often defined as a best corrected visual acuity of worse than either 20/40 or 20/60. [1]

Categories of visual impairment

Cate- gory	Corrected VA-better eye	WHO Definition Standard*	Working#	Indian Definition
0	6/6-6/18	Normal	Normal	Normal
1	<6/18-6/60	Visual Impairment	Low Vision	Low Vision
2	<6/60-3/60	Severe Visual Impairment	Low Vision	Blind
3	<3/60-1/60	Blind	Low Vision	Blind
4	<1/60-PL	Blind	Low Vision	Blind
5	NPL	Blind	Total Blindness	Total Blindness

The standard WHO definition is used in medical reports and publications and is solely based on visual acuity and does not take into account functional vision.

[2]

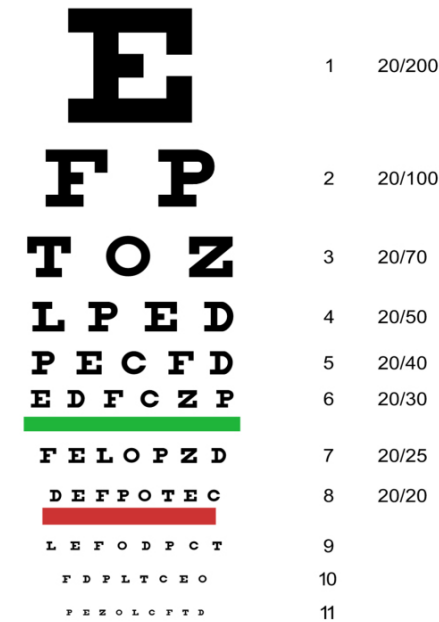


Fig 2. Snellen Visual acuity test chart

CAUSES

The following are the causes of visual impairment along with the percentage of their occurrence :

Refractive errors (43%),
Cataracts (33%), and
Glaucoma (2%).

Refractive errors include near sighted, far sighted, presbyopia, and astigmatism. Other disorders that may cause visual problems include age related macular degeneration, diabetic retinopathy, corneal clouding, childhood blindness, and a number of infections.

[1]

Understanding medical blindness

Visual impairment is the damage to any part of the eye that affects the normal functioning of the organ i.e. the eye. This disability can be measured with tests like the visual acuity test, color vision test, visual field test etc.

Visual Disability is the disability of a blind person to function normal everyday tasks and not the function of the eye organ.

Low Vision: Any bilateral loss of vision that cannot be corrected with eyeglasses or lenses that hinders the activity of the person.

Color Blindness: The inability to differentiate various shades of colors, particularly green and red, that others can easily distinguish. (Not a true form of blindness)

Night Blindness: The difficulty in seeing under low illumination, this defect in the eye is mostly acquired through genetic inheritance.

Snow Blindness: loss of vision due to exposure to large amounts of UV light, this is a temporary form of blindness and can be recovered later with appropriate treatments. [1]



Comparison between sighted and blind child

Excerpts from 'The Development of Perception and Learning in Blind Children' explaining why there is a learning gap between a blind child and a sighted child of the same age and intelligence:

- For a blind child, developing skill in effective use of the other senses is prerequisite for any further learning.
- A sighted child of same age and intelligence begins to use these skills for more complex learning.
- Eventually blind children develop skills but only with great expenditure of time and effort.
- Specific deliberate training in the perceptual skills becomes necessary from a very early age to minimize the learning gap between blind and sighted. [3]

Impact of visual impairment on development

Sensory development

For an infant born without sight, the other senses have intermittent input and may appear diminished. The child receives inconsistent, discrete, and generally unverified fragments of information.

Hearing is the only distance sense available to the blind infant. Sound without visual verification is only noise coming from nowhere. Only after much tactual, motor, and auditory interaction does sound acquire meaning. Only then can sound provide information about location, cause, or source.

Sound is not the strong motivator that vision is. Not until approximately 12 months - will a blind child reach for an object based on sound cue alone. Environmental exploration is usually delayed until the child reaches this point.

Motor development

Hands Although the hands are a major perceptual organ, a blind infant has significant developmental delays in his ability to employ his hands functionally.

Even at 5 months a blind infant's hands will be fisted and held at shoulder height. There will be no mutual fingering, no engaging at the mid-line. At this age, a sighted child is practicing coordinated reaching and transference of objects from one hand to another.[3]

This delay in hand utilization will result in delayed fine motor and gross motor development. .

Without vision, hand and eye do not work together. Instead, ear- hand coordination must occur. However this takes much experience and is achieved much later than normal eye- hand coordination.

Body

A blind infant usually achieves control of his posture at approximately the same age as sighted infants through the following normal progression:

- Sits alone momentarily
- Rolls from back to stomach
- Sits alone steadily
- Takes stepping movements when hands are held
- Stands alone
- Bridges on hands and knees

However, the achievements that require self- initiated mobility are significantly delayed:

- Elevated on arms in prone
- Raising to a sitting position
- Pulling to a stand
- Walking alone

The blind child's difficulty or reluctance in moving around the environment encourages passive behaviour such as self-stimulating mannerisms.[3]

Self- concept

The blind child has an unusual dependence on a sighted person to mediate and help integrate his environment. This notion of dependence must be considered as a major factor in the blind child's development.

The blind child has diminished control over his environment and can only control his inner world. As he withdraws into this world, he diminishes the need for social interaction.

He may not understand that there is a complex world outside of himself, that he is separate from it, that he can both act on it and be the recipient of action.[3]



Cognitive development

Construct of World

The blind child has limited ability to coordinate and organize elements into higher levels of abstraction, and to verify the information. Therefore, he constructs a reality that is different from the sighted child's. The process of establishing concept defining attributes and relationships is more problematic for the blind child and less accessible to guidance. The blind child is continually involved in problem solving, but this process, which is essential to future development, is more difficult and less rewarding for him.

Object Permanence

A stable visual field is the basis of object permanence and other conceptual tasks. Object permanence cannot be obtained by a blind child until he has the ability to reach for objects based on sound cue alone. It is acquired nearly a year later than in sighted children.

Causal Relationship

Since the results of actions cannot be seen, the blind child may not be motivated to action. He may not understand his ability to cause things to happen or to retain pleasurable stimuli.

Constancy

Understanding how to align blocks or orient his hands on a page in order to duplicate a pattern will be difficult if he hasn't observed objects in various orientations to know that an object is the same regardless of its position in space.[3]

Classification

Limited opportunities to explore objects and to see similarities are reflected in preschool blind children's classification errors. Concepts of same and different can evolve only if children identify the distinguishing variable on which to focus. A blind child has little difficulty generalizing across size, but numerous experiences with a variety of similar objects were required to expedite generalization and association skills.

Conservation

A blind child exhibits delays in conservation of substance, weight, volume, length and liquids.

Social development

Relationships

His/her social interactions are more complicated because subtle visual cues are missing and facial expressions are lost.

Self- Help

Many self-help skills that are normally learned by watching are delayed in blind children.

Chewing, scooping, self-feeding skills may be delayed 2 years or more. Brushing teeth is difficult to accomplish since the child may reject the texture and has no opportunity to observe others performing grooming skills.

Fear of the unknown and inability to locate the bathroom may contribute to delayed toilet training.[3]



Language development

Imitation

Much of what is learned by the normal child is learned by imitating others.

The blind child needs planned, systematic instruction directed at the development of deferred imitation.

Use of Language

The blind infant may jabber and imitate sooner than a sighted child, but may show delay when combining words to make his wants known.[3]

Senses of the visually impaired children

VISION

Visually impaired children live in a world with absence of color, light and visual stimulus. Hence they rely on auditory stimulus the most to understand their position in space and relative positions of other objects in the same environment. Inability to understand Shapes, patterns, contrasts at the early stages of development is a setback in learning and it takes more time compared to their sighted peers. Understanding of shapes comes from touch and feel of objects hence the touch sense plays a big role in understanding object constancy. Hand-eye coordination is lacking hence the hand-ear coordination needs to be developed quickly to foster their reflexes. The child cannot understand cause-effect-feedback relation during early development stages and is behind in this understanding compared to their sighted peers.

SOUND

Sound stimulates indicates source of activity or information and it helps the individual in orienting himself in space. Sound helps in identifying parents, siblings and friends. Infant has no control over the sound stimulus in his environment. Object permanence, which is, the understanding that an object remains in existence even when it is not directly observed takes time to develop and this development is heavily reliant on auditory stimulus.



TOUCH

The touch sense helps a blind individual understand surfaces, contours, differentiate textures, skin, clothes, differentiate food, and feel temperature. Often communication is also depended on touch and feel as holding of hands and feeling people's faces are a part of interacting with their loved ones.

SMELL & TASTE

Often times the visually disabled differentiate objects based on their material smell/ odour and taste too. Differentiating food taste and texture with the tongue is always a pleasurable way of enjoying food by both the sighted and the non sighted. Smell and taste are an often overlooked sense among the 5 senses.

3. Primary Research

- Understand the current scenario, validate/know more about the findings from the secondary data
- Find out problems/ difficulties, etc.
- Visit different places, analyse the existing products/aids/toys/ games(methods of information delivery)
- Find the opportunity/direction for the project.
- Classify and categorize different directions and approaches

Visits to Blind schools/ organizations

The literature study was followed by meeting visually impaired people. The following places were visited in order to gain a better understanding of their needs and requirements:

1. Model School for the Visually Handicapped- National Institute for the Empowerment of persons with Visual Disabilities (Divyangjan), Dehradun (NIVH)
2. National Association for Blind, Worli, Mumbai
3. Kumudhben Dwarkadas Vora Industrial Home for Blind Women, Mumbai.
4. Happy Home School for Blind, Worli
5. Workshop by Xavier's Resource Center for the Visually Challenged (XRCVC).



Fig 3. Classes being held out in the sun for Students in NIVH

1. Model School for the Visually Handicapped - National Institute for the Empowerment of persons with Visual Disabilities (Divyangjan), Dehradun (NIVH)

The National Institute for the Empowerment of Persons with Visual Disabilities (Divyangjan) (NIEPVD) at 116, Rajpur Road, Dehradun is one of the seven National Institutes working under the administrative control of the Department of Empowerment of Persons with Disabilities (DEPwDs), Ministry of Social Justice & Empowerment, Government of India.

The benefits offered by school include free education, board and lodging, uniform, books and equipments. The school provides an environment that encourages a questioning mind and gives students many avenues for expressing their creativity and building their skills. [5]

Interviews

Interview 1, MR. Sushil Kumar (Music teacher)

The difference that Mr. Sushil highlighted during the interview amongst sighted and non- sighted students were as follows:

- Can't take notes while being taught
- The students have to memorise every line
- Takes more time for them to learn
- Have to be taught practically
- They learn theory through Braille books
- They are taught Harmonium and Tabla

Interview 2, Amit Singh (Computer teacher)

- Can't understand graphical interfaces
- They use normal keyboards instead of Braille keyboards
- They cannot figure out if the computer malfunctions
- Cannot install an operating system (since the system doesn't provide feedback).
- Totally dependant on audio feedback.



Fig 4. Computer lessons being held for the students

Interview 3, Shashi Ma'am, Teacher (Kindergarten)

- The children are taught to differentiate between textures (sensory training).
- Taught shapes and introduced to them through toys and models
- Taught Braille through different games and toys
- Introduced to tastes.
- Also introduced to alphabets through board games

Interview 4, Asha , Attendant (junior school)

The attendant helped the younger students with the following:

- Making the children feel comfortable who have come away from their house for the first time.
- Helping them with learning living skills
- Helping them get acquainted to other fellow students
- Taking care of them during school.
- Giving them love and affection.

Interview 5, Sandeep Kumar (Mathematics teacher)

- Difficulty in construction of diagrams, the students are totally dependent on the efforts of the teacher.
- It's not possible to draw a diagram and write in Braille on the same paper without changing the base.
- No considerable changes have been made in the mathematics kits over years.



Fig 5. Class I students with the attendant

Experience

My visit to NIVH was quiet enlightening for me. It was my first close experience with Blind people and students. I was surprised to find out that the visually disabled students worked with similar motivation or even more than the sighted students. The number of activities carried out in the school were same as school for the sighted students.

Not just the students but also the teachers were highly driven to teach these students as they all gave me enough time and discussed the needs and requirements of the students. I actively observed the student - teacher interaction and the course of the classrooms. It is highly different from a normal classroom as the students required more undivided individual attention of the teachers. Also, multiple concepts required a fair amount of effort by the teachers to reach out to the students.

The teachers were using Teaching Aids/ Materials to explain even the most complicated topics to the students. These aids were made in - house with simple materials but they surprisingly reduced the major fraction of effort.



Fig 6. Student writing in Braille during an exam



Fig 7. Students posing for a picture at NIVH



Fig 8. Teacher helping a student using a teaching aid



Fig 10. Students playing with animal toys



Fig 9. Students at a game of Blind chess

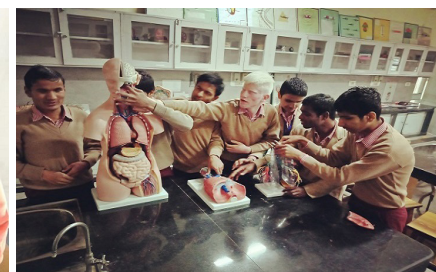


Fig 11. Biology classes being conducted using teaching aids

2. National Association for Blind, Worli, Mumbai

Empowered and well-informed visually challenged population of our country, thus enabling them to lead a life of dignity and productivity.

MISSION

Prevention of preventable and cure of curable visual impairment.

Socio-economic rehabilitation of the visually challenged in mainstream, through education, training and employment.

To take up advocacy against all types of individual and structural discrimination and ensure full legal capacity.

Assure accessibility to the world of information.
[6]



Fig 12. A Visually disabled women using electronic Braille Reader for Proof-reading at Braille Press, NAB

The visit to NAB included a very informative walk around the NAB centre at Worli where we got the opportunity to get to know the operation of the Braille Press and, the Recording Studio and the Braille Library. We were made aware of the working of the organisation.

In regard to my project, I visited the education department of NAB and got to interact with the teachers present there.

I procured multiple education related products from the centre, which later helped me in taking my project forward.



Fig 13. An interaction with Blind B.Ed Students



Fig 14. Interaction with Blind people at NAB Vocational Training Centre.



Fig 15. Getting to know the need of Adult Blind people



Fig 16. Interaction with Blind people at NAB Vocational Training Centre.

3. Kumudhben Dwarkadas Vora Industrial Home for Blind Women, Mumbai.

This is an Industrial home for unmarried blind women, which is run by Non- government organisations. They provide a 3- year training to the women and help them become self- dependent for the later phases of their life. The institute provides them the following;

- Free Boarding Lodging
- Vocational Training
- Braille Training
- Medical Aids
- Skill training (Weaving, Tailoring, Broom Making, cooking etc.)

I interacted with Mrs. Chitra Deshmukh who briefed us about the institute and its working and was also very supportive to let us interact with the women of the institute.



Fig 18. Paper- bag making activity at the institute



Fig 17. Blind Women weaving at the institute

4. Happy Home School for Blind, Worli

...where children with visual / multiple impairment begin their first steps to understand their environment and the need to learn that their world is connected to what they hear, feel, touch but cannot see.

Those first steps were taken 88 years ago in a restricted, rented space with only five blind boys.

...Today, The Happy Home & School for the Blind is a special place where 200 happy, smiling boys cross barriers of language, religion and creed and make you forget trivial problems.

The Happy Home & School for the Blind is truly a celebration of the 13th Century Prayer....

“Make me an instrument of your peace, Where there is darkness, let there be light, Where there is sadness, joy.”- St. Francis of Assisi [9]



Fig 19. Happy home school for blind, Worli

My visit to Happy Home School for Blind, Worli was rather a disappointing one. I met the principal of the school who also was the mathematics teacher. The school management did not allow me to interact or observe the students but I got the opportunity to speak with the Principal about my area of interest which was “geometry for Blind Students”. She told me that the school has not included geometry in the mathematics syllabus for students as they think that they cannot learn it properly. She also mentioned that the visually disabled students must restrict themselves to the topics where they can perform better and not take much risks.



Fig 20. Logo of the school



Fig 22. Students form Happy Home School for Blind



Fig 21. Classes held at Happy Home School for Blind



5. Workshop by Xavier's Resource Center for the Visually Challenged (XRCVC).

ABOUT US

The Xavier's Resource Centre for the Visually Challenged (XRCVC) is an integral part and department of St. Xavier's College - Autonomous, Mumbai.

The XRCVC was started in 2003 as an effort to ensure an inclusive environment at St. Xavier's College, one of the most well-known educational institutions in the country, for its students with blindness and low vision. Having created an inclusive set-up for its own students, keeping with the college's long tradition of creating social impact within the larger community, the XRCVC has today become a national advocacy and support centre for the blind and low-vision across the city and the country.

Our Vision is to work towards creating an enabling environment to facilitate the development of an inclusive society, both at the micro as well as the macro levels, thereby providing equal opportunities for holistic growth for the visually challenged.

A Workshop "Design for Blind" was conducted by Mr. Krishna Warriar, at IDC- IIT Bombay. This workshop sensitised me towards designing for Blind and its importance as well.

The workshop majorly constituted of us conducting everyday tasks with blind folds, the workshop gave us a glimpse of how is it like to not have vision. It was astonishing to see that our other senses become highly aware when we are deprived of vision.



Fig 24. Logo of Xavier's Resource Center for the Visually Challenged (XRCVC).

Selection of area of interest

In the absence of vision, access of diagrams becomes a serious challenge for persons with blindness especially in subjects like Science and Mathematics where majority of concepts are conveyed through diagrams. It often leads to exclusion of a student in an inclusive classrooms where sighted students easily learn concepts through diagrams and a student with blindness is left with no option expect to image the diagram by listening or reading the related text. As a result, majority of students have to drop Science and Mathematics subjects in higher classes.

After analysing the findings of all the visits conducted and a detailed discussion with my guide the chosen area was Educational Products- geometry aids. The need for design intervention in this area was also suggested by Mr. Sandeep Kumar, the mathematics teacher at NIVH, Dehradun .

Educational Products

The need for design intervention in this area was also suggested by Mr. Sandeep Kumar, the mathematics teacher at NIVH, Dehradun . Moreover, after visiting multiple institutes and organizations it was realised that there was a need for an intervention for the students to learn and construct diagrams in geometry as it is getting redundant from the syllabus of multiple Blind schools in India.

Skill Development

This area has an opportunity for design intervention. Developing/ designing products for the blind children to develop basic skills such as motor, sensory, orientation and mobility, which will help them to overcome multiple obstacles in life.

Vocational Training

An area, in which developing products for children to develop skills related to vocational training, which will help them to earn for themselves.

4. Market Study

Trying to improve my “Tactile Vocabulary” by studying the existing products in the field of education for the blind

Specific study of existing products procured from multiple places.

Teaching and Learning Aids/ Materials

TACTILE TOYS



Fig 25. Tactile toys



Fig 26. Tactile toys (animal toys)

These toys are used for kindergarten students to make them understand different volumes, and also textures and shapes. This is their introduction to general objects. It helps them increase their visualization skills. Improving fine motor skills, understanding patterns, classifying objects based on size, weight etc,

Advantage

Provide a Sense of touch and texture

Disadvantage

Occupy a lot of shelf space

MOTOR SKILLS GAME



Fig 27. Motor skills game



Fig 28. Motor skills game

Simple toys that requires toddlers to differentiate objects by size and drive them through stiff bent wires. Objects are usually geometric shapes and made in hard plastics like ABS or even wooden blocks.

Improving fine motor skills, understanding patterns, classifying objects based on size, weight etc, following a path.

Advantage

Easy to understand
Easy to play with
Robust

Disadvantage

Heavy -made out of wood
The pieces can fall out if tilted and shaken and can go missing since there is no feature to remain in the slots.

BRaille TEACHING

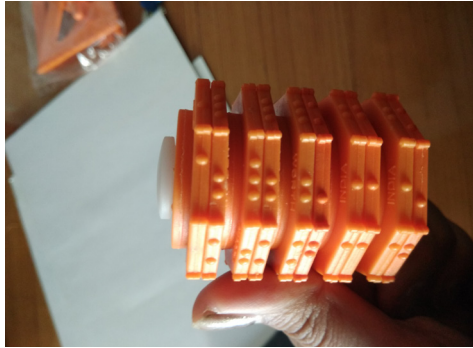


Fig 29. Braille teaching device



Fig 30. Braille teaching device

Cubical Braille teaching device with 3 rotating faces containing raised dots in different arrangements that represent Braille impressions. The faces can be rotated and new Braille letters and alphabets be formed.

Advantage

Easy to manufacture, safe materials, fun to play, teaches Braille.

Disadvantage

Lack of multi-sensory feedbacks

TEACHING AIDS (4-6 YRS)



Fig 31. Number Cutout

Number and alphabet cut-outs to introduce the actual shapes and form of alphabets .

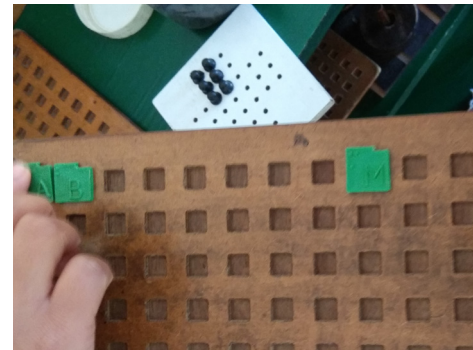


Fig 32. Braille scrabble

Helps in learning and recognizing Braille numbers and alphabets

Advantage

Universal Design

ADAPTED GAMES FOR VISUALLY DISABLED



Fig 33. Adapted Chess

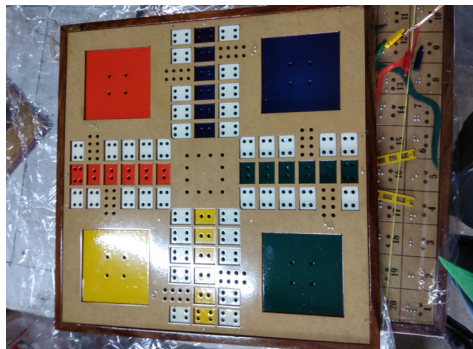


Fig 36. Adapted Ludo

These games are common board games and other similar toys which have been adapted to play for children with visual disability. The normal game play has been improved upon with the addition of textures and Braille to make it easier for blind users to map and play the game.

Advantage

The advantage of these games are that they can be played along with sighted children as well. Helps in increasing social interaction and communication.

MATHEMATICS TOOLS



Fig 34. Taylor frame

There are adapted tools as well as specially designed tools for visually disabled students to solve mathematical problems.

Taylor frame helps the students to solve algebra and arithmetic mathematical problems.



Fig 35. Taylor Frame Coins

The problems are solved by placing the coins in the frame and by orienting them at different angles.

Disadvantage

Heavy Weight
Easy to loose the coins

Geometry Kits

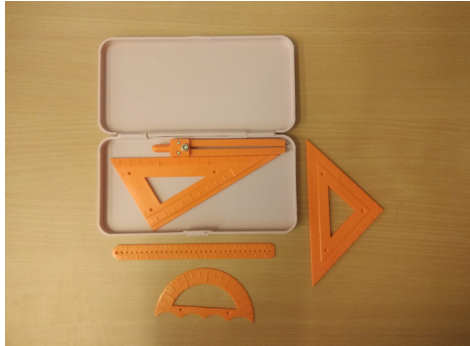


Fig 37. Mini Plastic Geometry set

Mini Plastic Geometry Set

Retrieved from **NAB ,Worli**

Very similar to the existing geometry set for sighted. Small and compact
Made out of plastic- durable, long lasting.

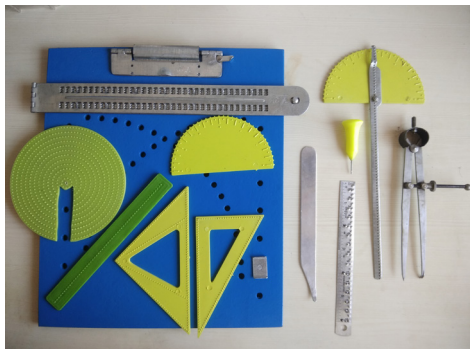


Fig 39. Rubber Based Geometry Kit

Rubber Based Geometry Kit

Retrieved from **NIVH, Dehradun**

Tactile embossing method used for construction
Used for Basic constructions
Robust
Out-dated(is not used anymore)

TEACHING AIDS (4-6 YRS)

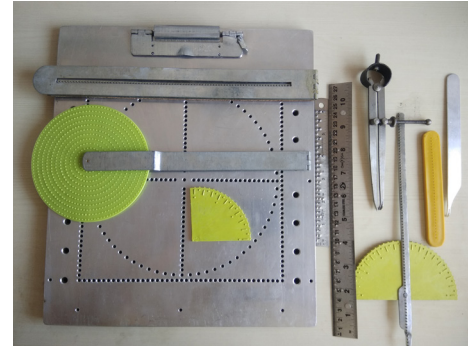


Fig 38. Versatile geometry kit (aluminium base with embossed accessories)

Versatile geometry kit (aluminium base with embossed accessories)

Retrieved from **NIVH, Dehradun**



Fig 40. Plastic And Rubber Geometry Kit (With Embossed Accessories)

Plastic and rubber geometry kit (with Embossed accessories)

Retrieved from **NAB ,Worli**

Versatile geometry kit

(aluminium base with embossed accessories)

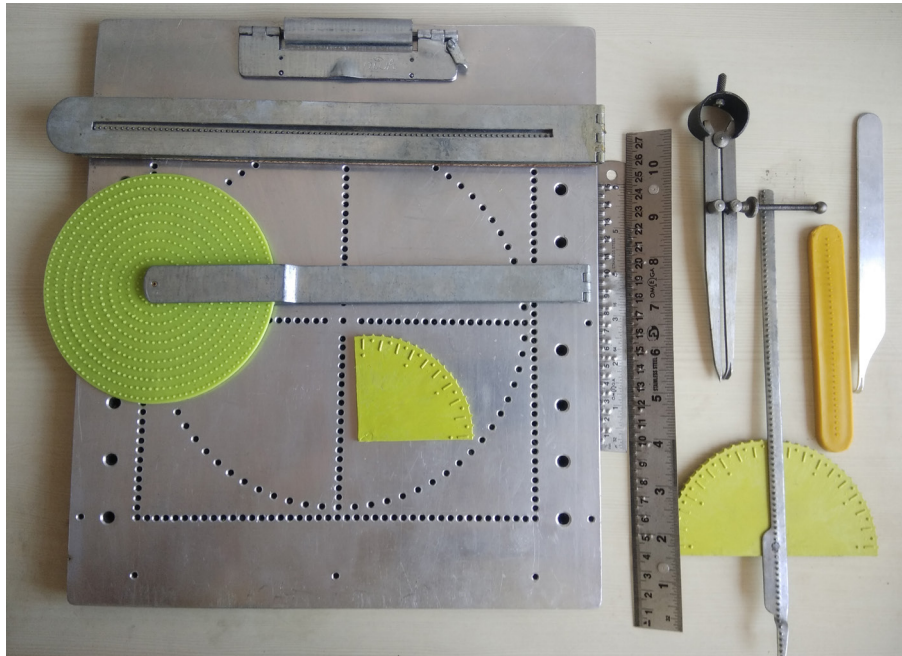


Fig 41. Versatile geometry kit (aluminium base with embossed accessories)

COMPONENTS

- Slate (Base)
- 30cm Embossed Ruler
- 15cm Embossed Ruler
- Circle Master
- Protractor (measuring and drawing angles)
- Compass
- Guide for drawing lines
- Small guide for lines
- Stylus for drawing.
- 90 Protractor for measurement (embossed)



Fig 42. Orienting the slate on the table.



Fig 43. Fixing the paper (Orienting the paper)



Fig 44. Locking the paper

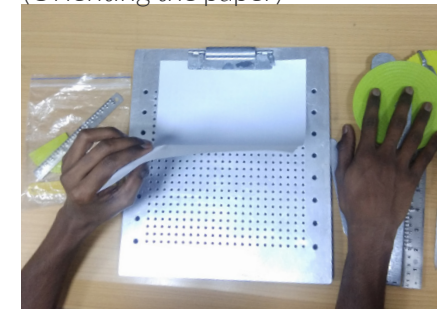


Fig 45. Placing the instruments on the table.



Fig 46. Carrying out the task (Drawing line, arc, circle)



Fig 47. Getting the perfect quality of emboss.

- Replacing and locating the instrument.
- Writing in Braille over the same sheet.
- Packing and putting the instruments back.
- Carrying the instruments around.

Observations

Slate

- Too heavy
- Difficulty in locking and unlocking for fixing paper
- Inconvenience in locking the clip.
- Edge of the sheet of paper and end of the slate alignment.
- Locking mechanism tends to tear the paper if the paper and the slate is not aligned.



Fig 48. Clamping the paper

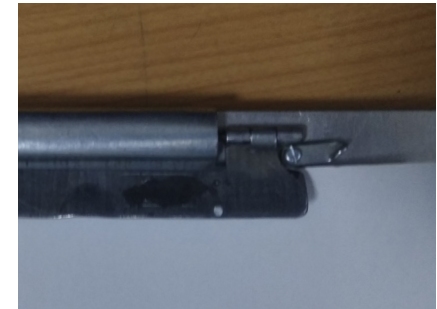


Fig 49. Inconvenience in locking the clip.

- The paper goes underneath the clip while fixing.
- Gives feedback when the lock is closed properly
- Need to flip the paper every-time to draw or write on the same sheet.
- the grid is not 1cm x 1 cm.
- Not very precise.
- Direct Drawing Geometry kit.



Fig 50. paper goes underneath the clip



30CM RULER

- The markings are not precise and are confusing.
- Sharp edges
- Easily manufacturable.
- Low cost



Fig 51. markings are not precise and are confusing.



15CM RULER

- Not precise markings, difficult to count and measure.
- No Braille feedback available.

CIRCLE MASTER

- Difficult to locate the center from the top of the paper.
- Sharp pin at the bottom.
- The top flap might fold the paper (might not coincide with the width of the paper).
- Limitation of Radius.
- Measuring the radius from over the sheet is difficult.
- Matching the radius of the compass and the same radius of the arc is also difficult.
- Putting the compass at the centre, difficulty in locating the centre of the circle.

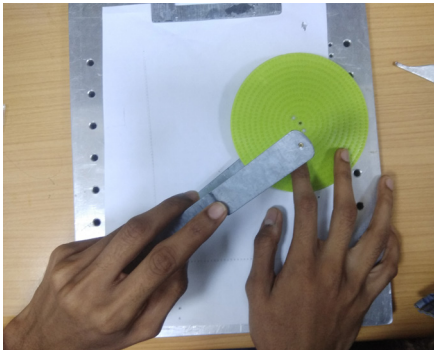


Fig 52. Difficult to locate the center

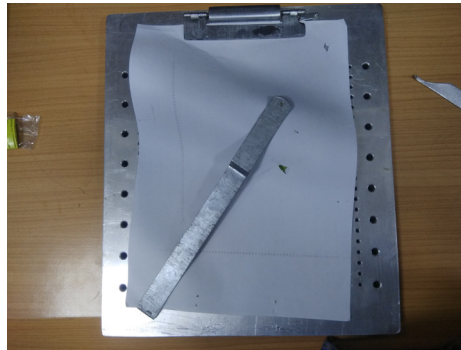


Fig 53. top flap might fold the paper

PROTRACTOR

- Finding the centre for making the angle is difficult.
- Bad quality of lines.
- It is difficult to measure angles from the device due to the difference in depth.

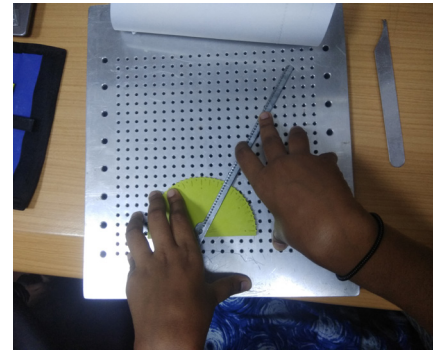


Fig 54. Bad quality of lines

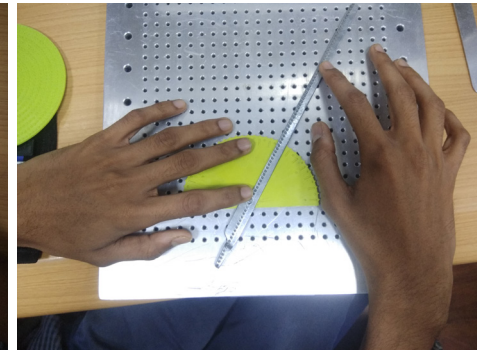


Fig 55. Finding the centre for making the angle is difficult.

POINTS OF REFERENCE

- Cannot be named or recognized later.
- Sharp
- Difficult to grip.
- Tend to get lost and hard to relocate.

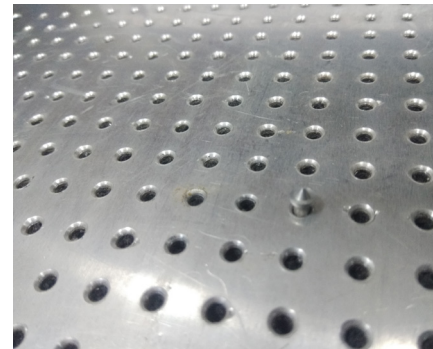


Fig 56. Small and difficult to grip

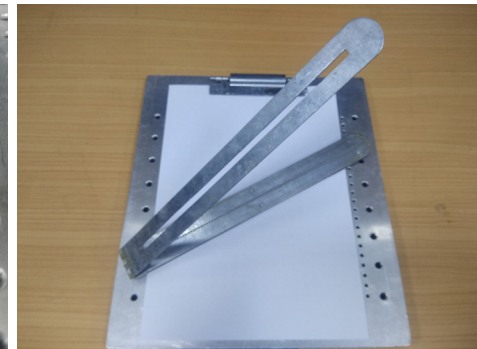


Fig 57. Drawing straight lines

GUIDE FOR DRAWING LINES

- Can't construct a line segment of a definite length.
- Aligning the guide on points if there are more than two reference points is problematic since the guide may lie on all three points.
- The flap of the guide may tend to fold the paper.
- Heavy weight.



Fig 58. Stylus



Fig 59. Compass

STYLUS

- Doesn't have a good grip.
- The stylus is off-balanced.

COMPASS

- Cannot be used for constructing arcs
- Only works with a base guide.
- Limited radius.
- Tears off paper.
- Difficult to adjust the radius with one hand

Plastic And Rubber Geometry Kit (With Embossed Accessories)



Fig 60. Plastic And Rubber Geometry Kit (With Embossed Accessories)

COMPONENTS

- Slate (Rubber Base)
- 30cm Embossed Ruler
- Protractor (measuring and drawing angles)
- Compass
- Spur wheels
- 2 Triangle rulers

Observations

SLATE (RUBBER BASE)

- Too much pressure is required to make impressions on paper.
- Does not have any reference points or guides
- Difficult to draw parallel lines and can't have reference points.

RULER(EMBOSSED)

- Provides feedback only through touch.
- Doesn't provide any other feedback like auditory feedback.
- Difficult to draw a line segment of certain length.
- Have to count every-time to measure.
- No resting space for compass while fixing the radius.
- More precise than aluminium geometry kit.

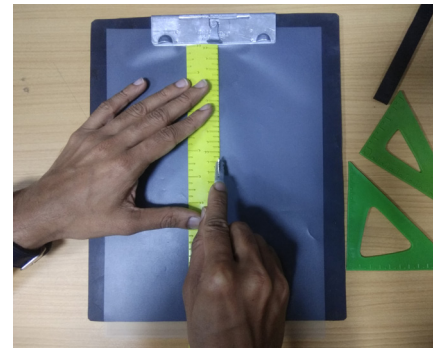


Fig 61. Too much pressure is required

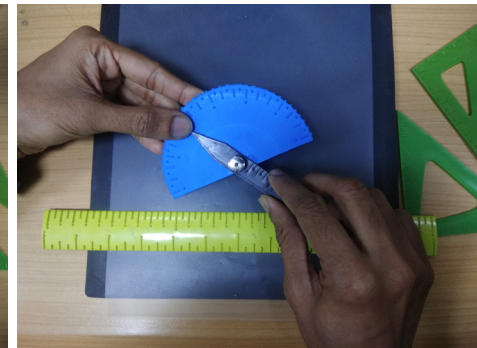


Fig 62. Protractor required

PROTRACTOR

- The pointer is not precise, does not point exactly at the angles. (could have given tactile feedback)
- Difficult to coordinate between the pointer and the angle marking.
- Need to count every time from one corner.

SPUR WHEELS

- The thickness of the scale is more than the radius of spur wheel.
- Doesn't align with the guides, tends to draw curved lines.
- Requires a lot of pressure to be applied.
- Grip is not ergonomic.
- Shall be held at 90 degree.



Fig 63. Grip is not ergonomic.



Fig 64. thickness of the scale is more than the radius of spur wheel

COMPASS

- Difficulty in adjusting the radius (turning the wheel with one hand to fix the radius)
- Limited radius options.
- Can't fix them at a point.
- The spur wheel goes over the rulers while drafting.

2 TRIANGLE RULERS

- Can't fix them at a point.
- The spur wheel goes over the rulers while drafting.



Fig 65. Compass

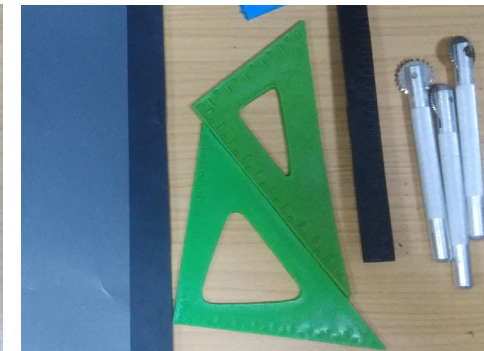


Fig 66. 2 Triangle Rulers

5. Design Brief

To design a geometry kit for visually impaired school students between classes 5th to 8th to aid them construct geometric diagrams.

Users & Target Market Segment

- Visually Impaired kids between classes 5th to 8th.
- Schools following NCERT syllabus.

User Requirement

- Should be easy to learn (Reducing the learning curve)
- Should be easy to use
- Easy to carry around
- Should have the option to write on the same medium
- May also help in learning the concepts
- Should be safe to use

Broad Product Specifications

- Should be light in weight
- Should fit into a regular sized school bag

Design Considerations

- The Students must be trained with the essential motor skills.
- Also, they must have the basic knowledge of geometric concepts as taught in junior classes

The Approach

To define the tasks to be carried out by the geometry kit, a thorough study of the syllabus of NCERT mathematics was carried out. In Principle, to draw geometrical shapes and geometrical constructions, we need tools to draw the following:

- Point
- Line and Line Segment
- Circle and Arc
- Angle between two lines

Geometric Construction Syllabus

Class VI

(using Straight edge Scale, protractor, compasses)

- Drawing of a line segment
- Construction of circle
- Perpendicular bisector
- Construction of angles (using protractor)
- Angle 60° , 120° (Using Compasses)
- Angle bisector- making angles of 30° , 45° , 90° etc. (using compasses)
- Angle equal to a given angle (using compass)
- Drawing a line perpendicular to a given line from a point a) on the line b) outside the line.[9]

Class VII

- Construction of a line parallel to a given line from a point outside it.(Simple proof as remark with the reasoning of alternate angles)
- Construction of simple triangles. Like given three sides, given a side and two angles on it, given two sides and the angle between them.[9]

Class VIII

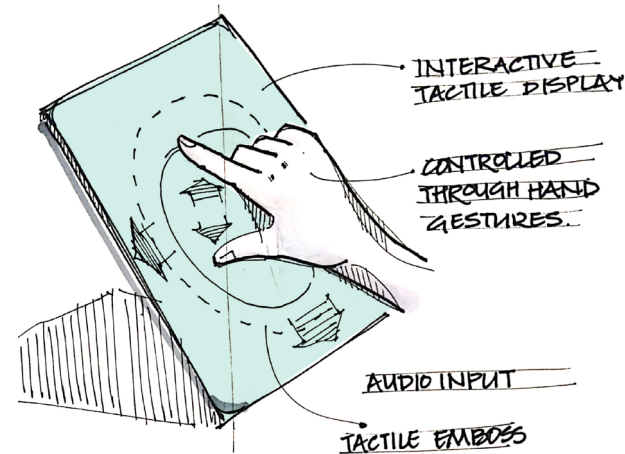
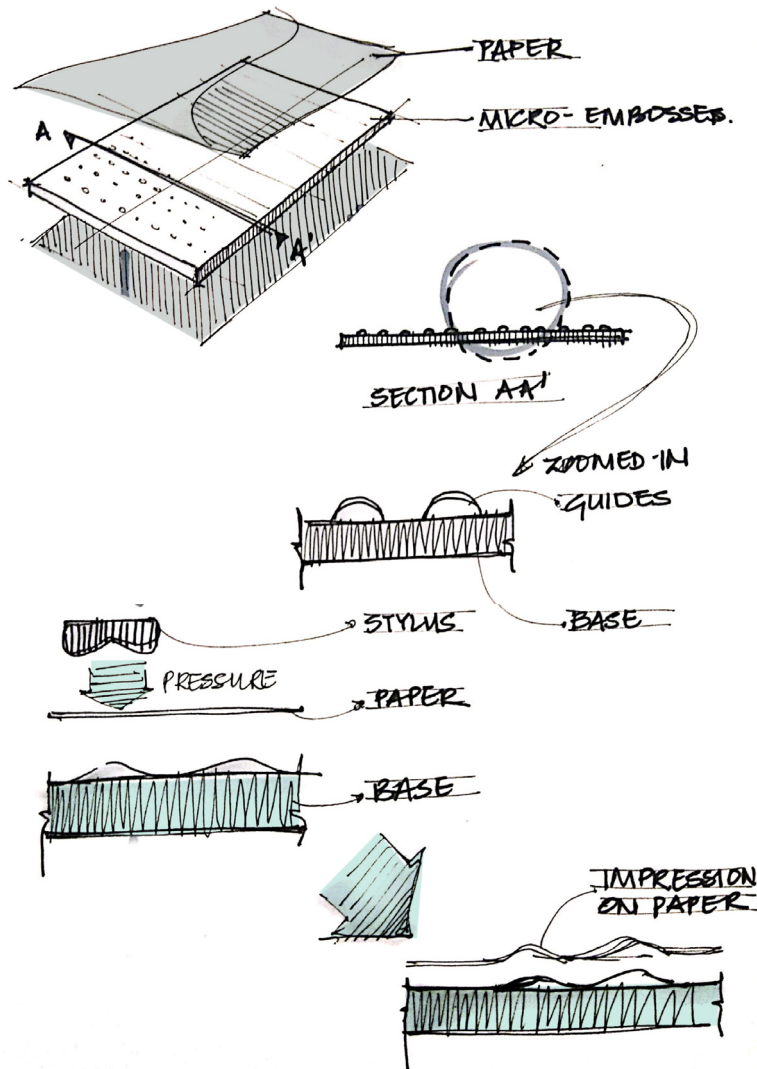
Construction of Quadrilaterals:

- Given four sides and one diagonal
- Three sides and two diagonals
- Three sides and two included angles
- Two adjacent sides and three angles[9]

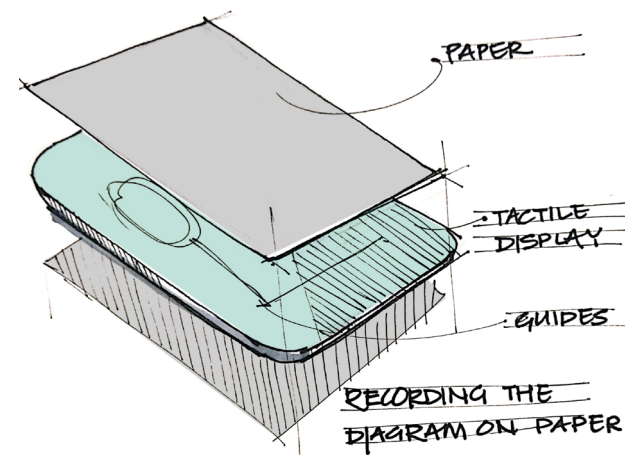
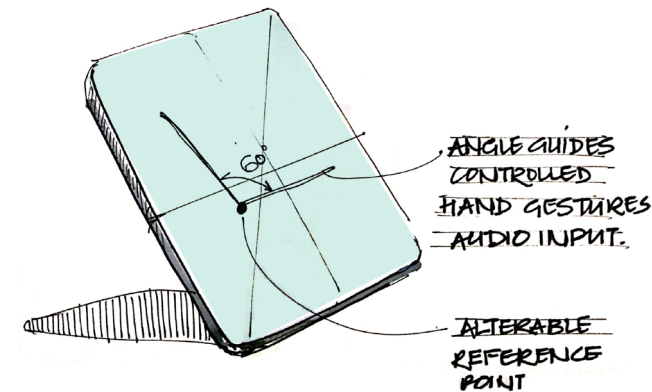
6. Ideation

Ideas for the base

A micro embossed surface or a textured surface over which a stylus could apply pressure to create impressions on paper.
Or a textured surface over which a softer material like wax can form impressions.



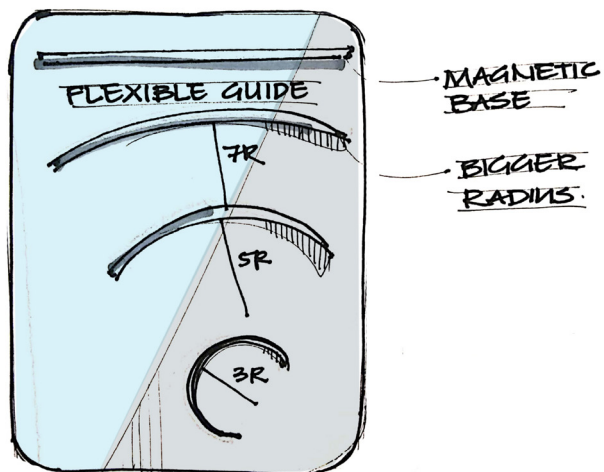
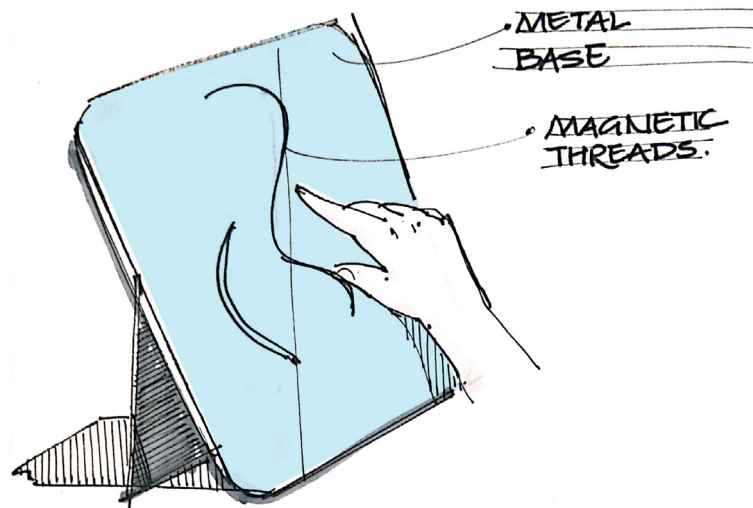
An interactive tactile surface which can be prompted to create tactile impressions over itself through hand gestures and movements.



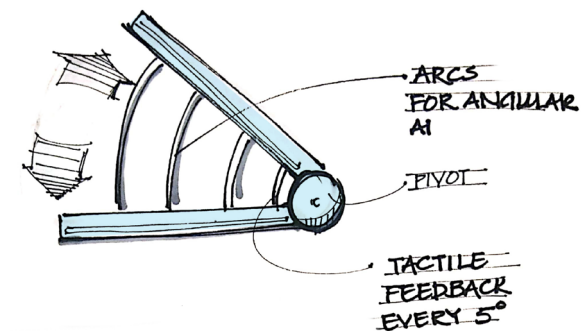
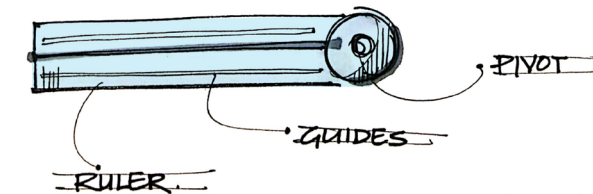
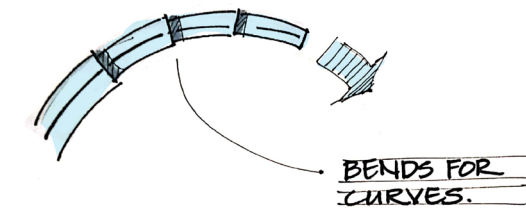
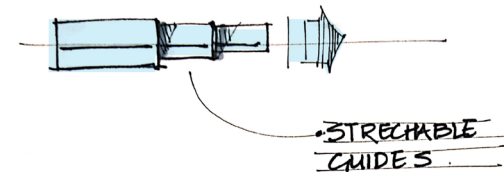
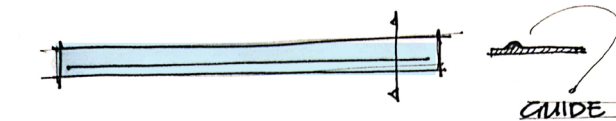
Direct Drawing by placing guides underneath the paper. Fixing the next step and then drawing over the paper to create emboss.

Ideas for the guides

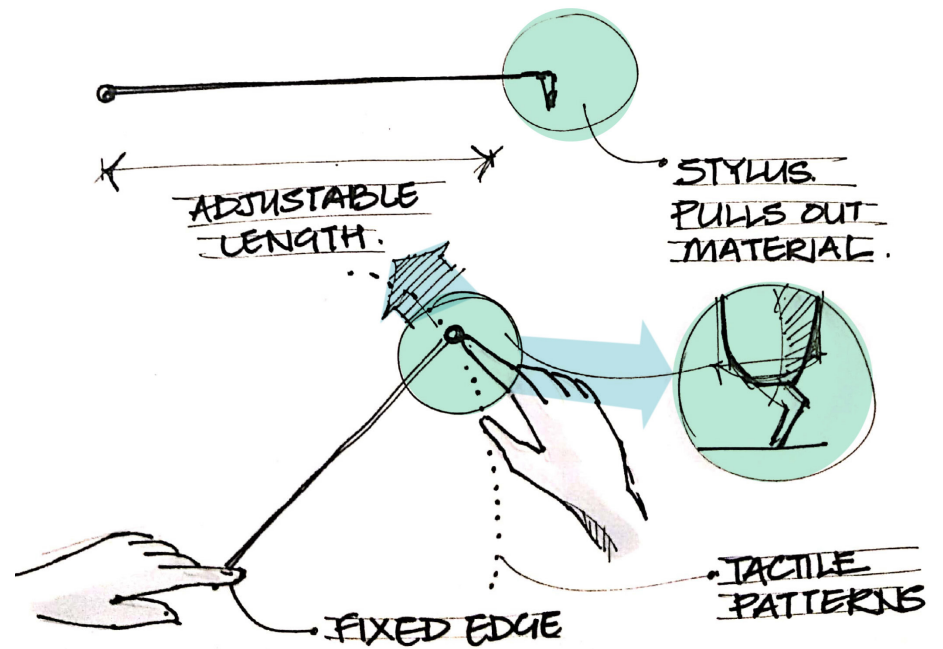
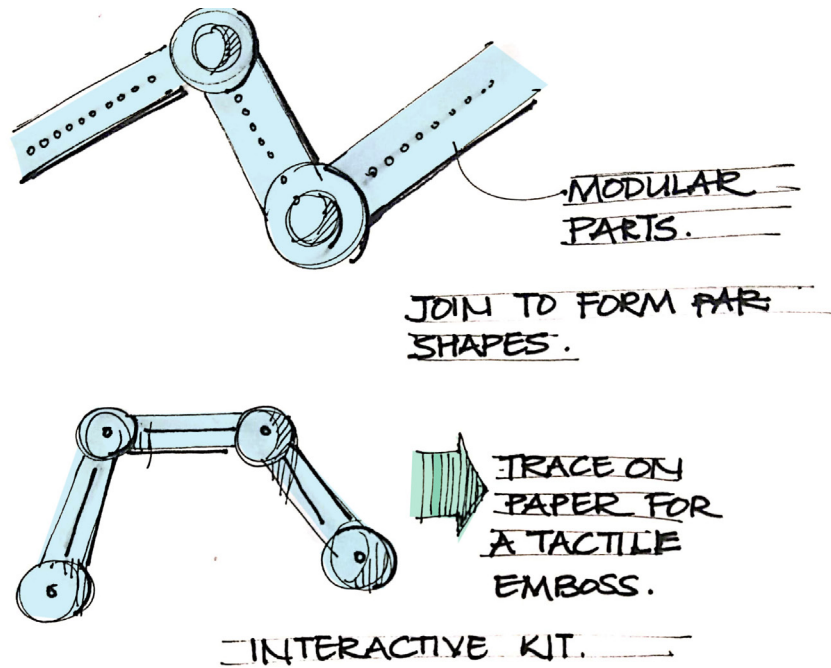
Magnetic and flexible guides for direct drawing on paper. They can stick onto a metallic base and help in forming a diagram before hand.



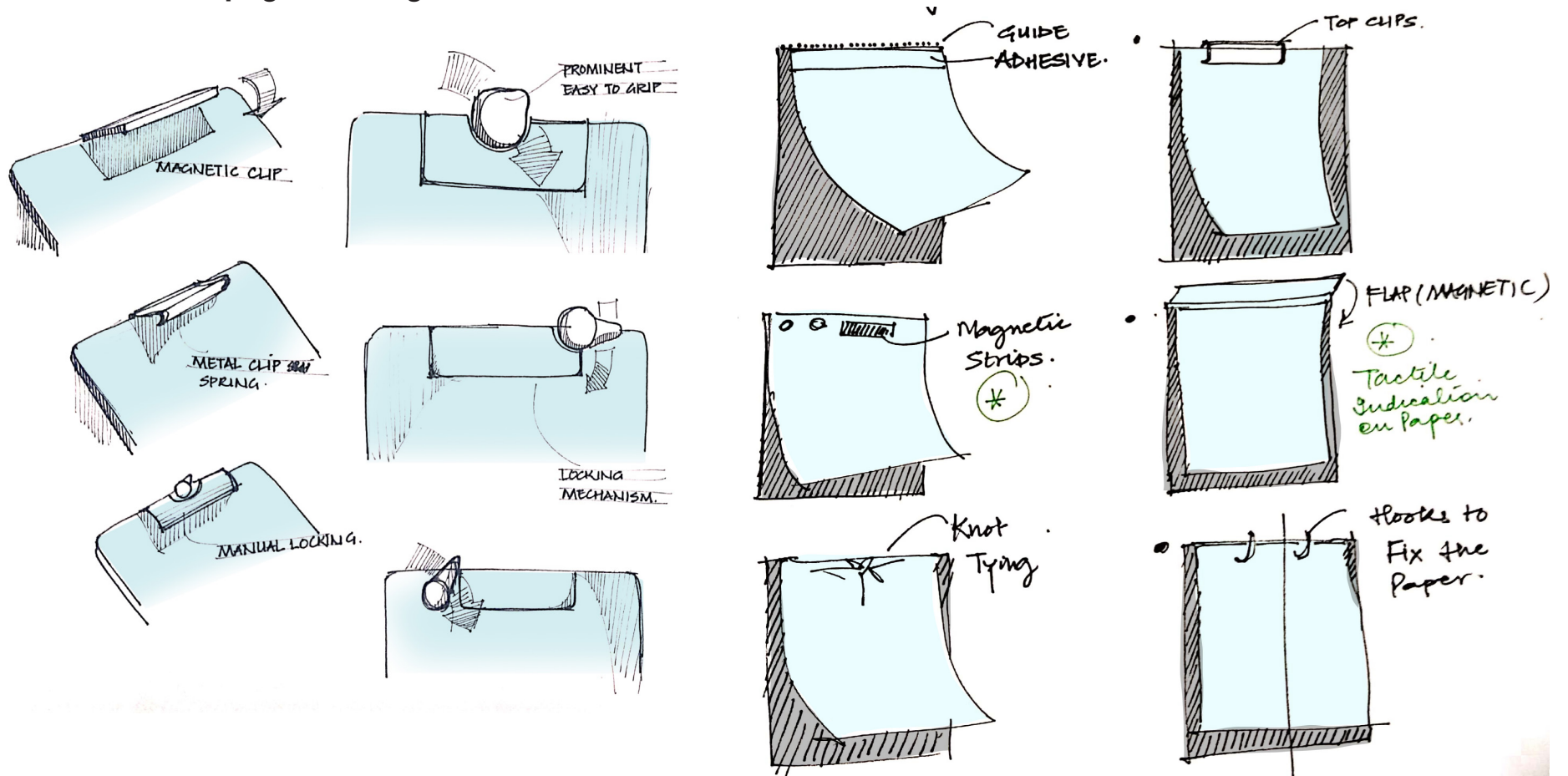
Stretchable guides and flexible ones to form arcs and lines and angles on paper.



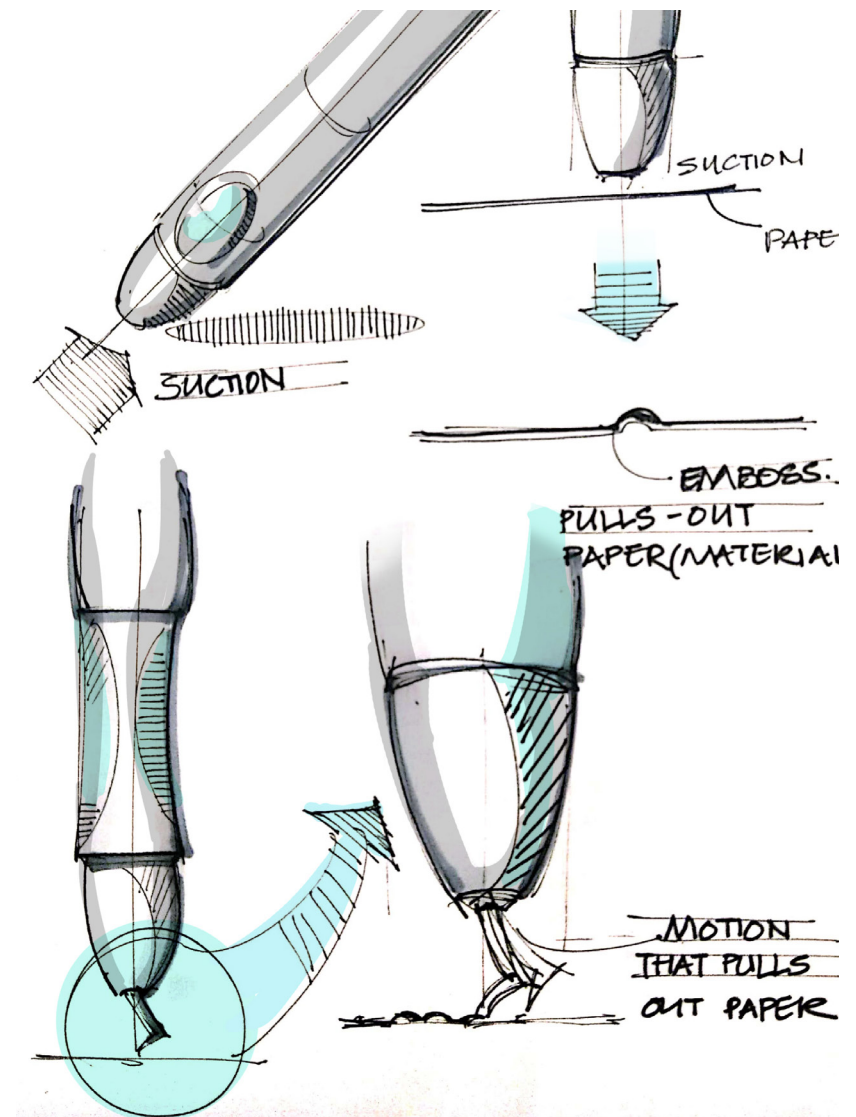
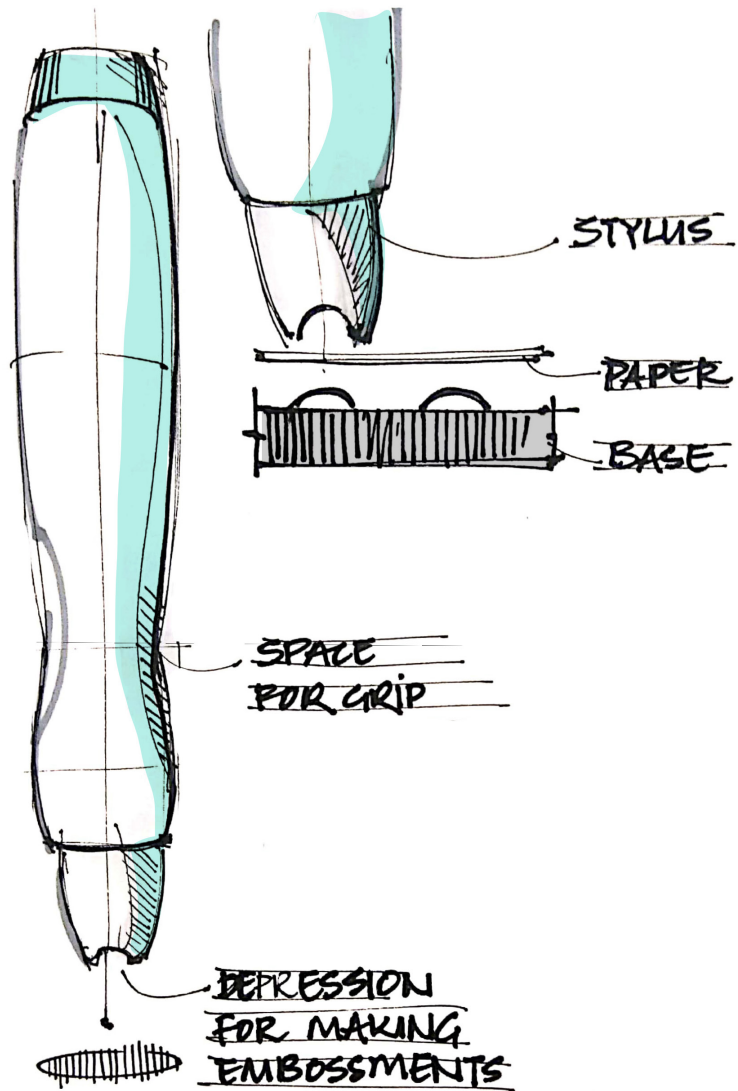
Modular guides which can help in forming angles and quadrilaterals and multiple closed shapes.



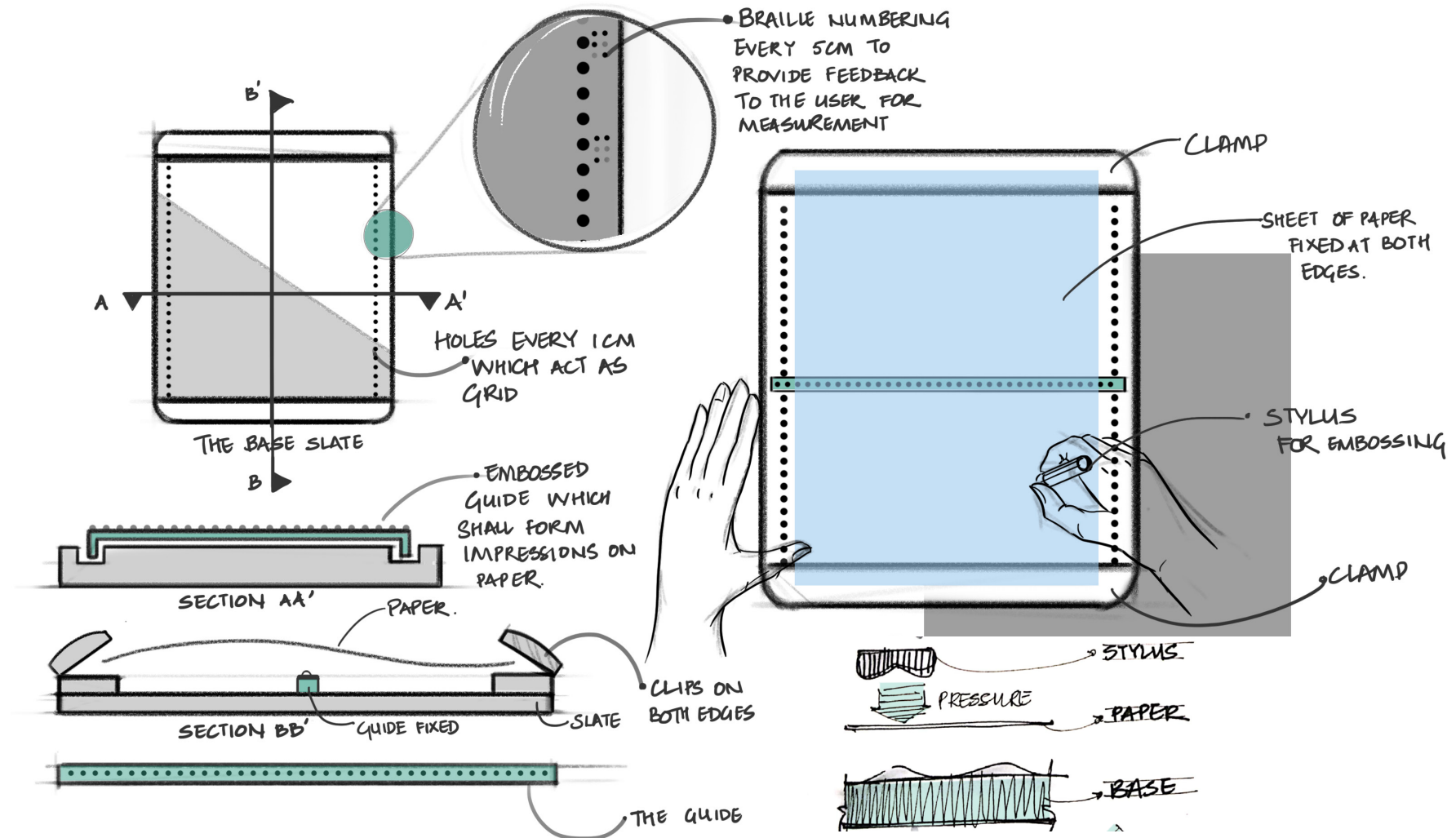
Ideas for the Clamping and locking



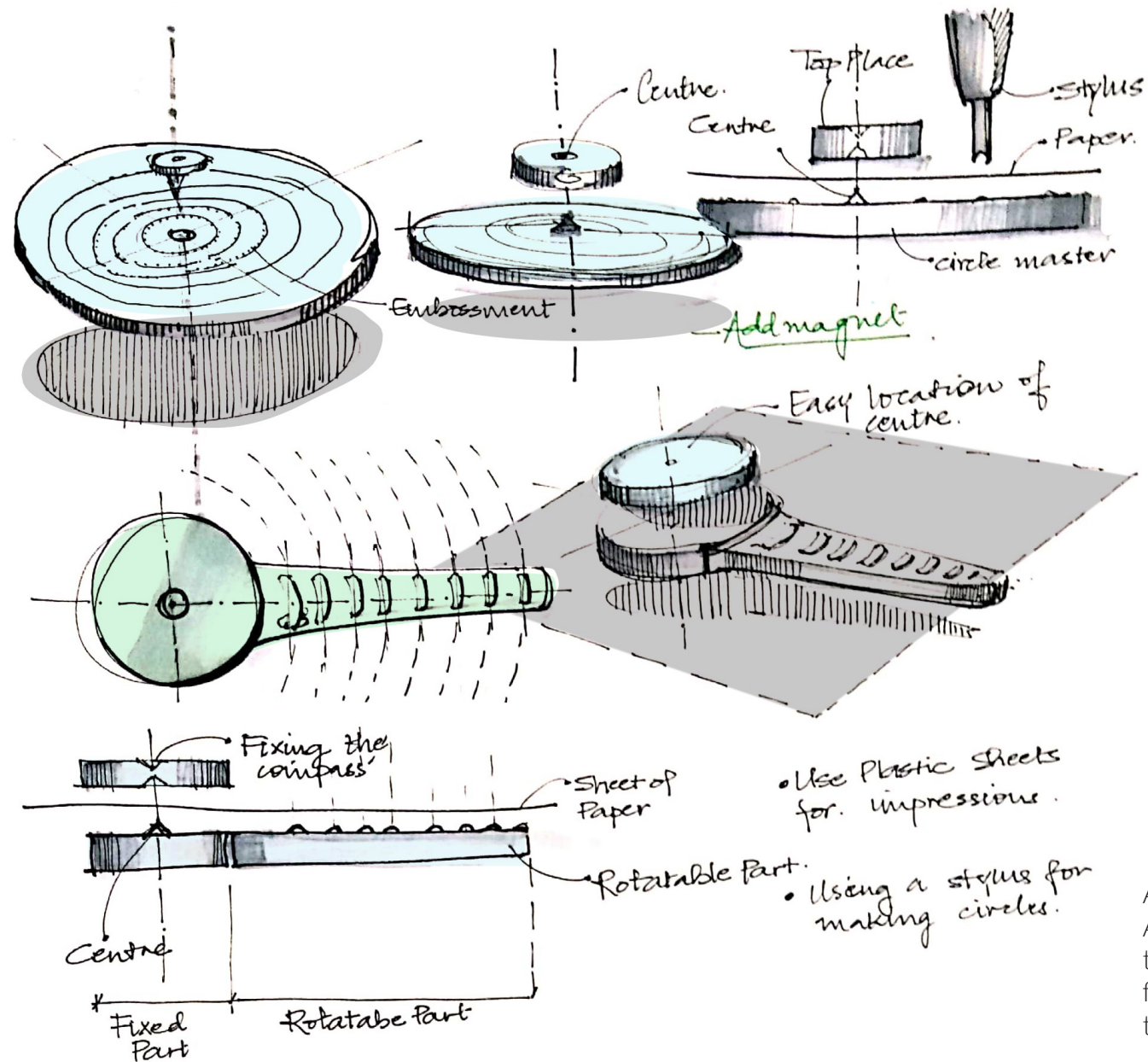
Ideas for the stylus



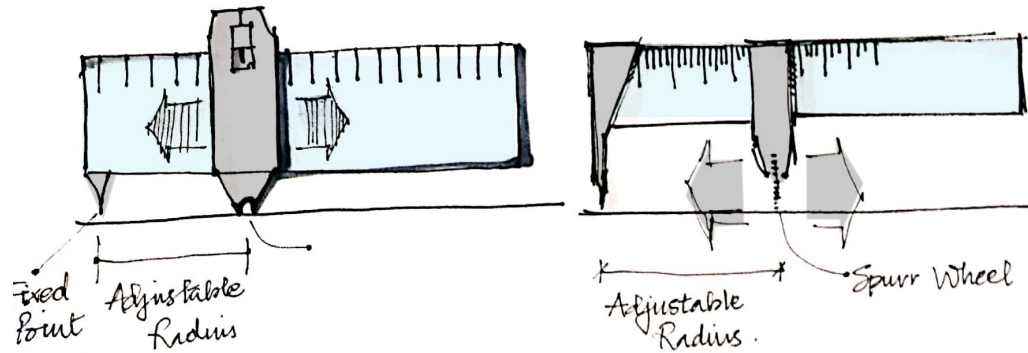
Ideas for the Grids



Ideas for the Circles and Arcs



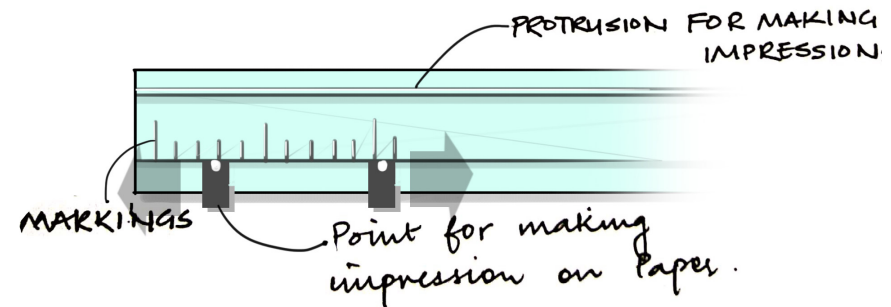
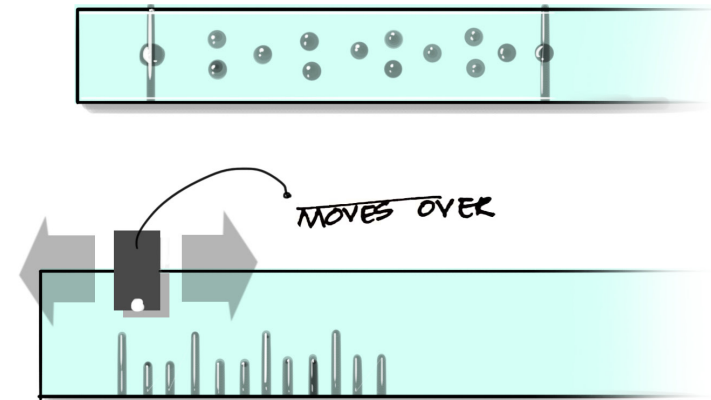
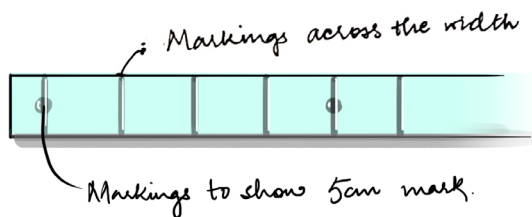
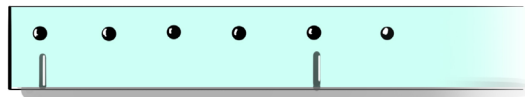
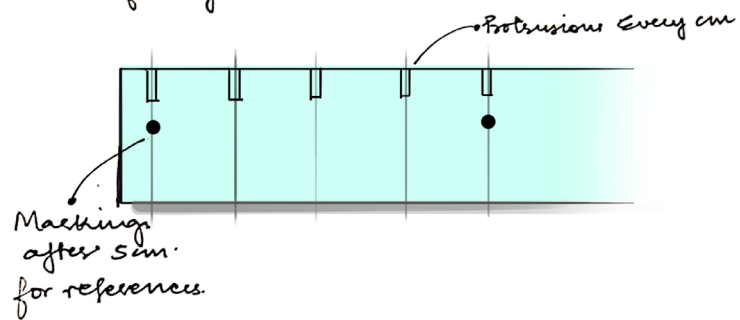
A device for drawing circles. A revolving grid beneath the paper which shall help in forming circles and arc over the paper.



Ideas for the Rulers and markings

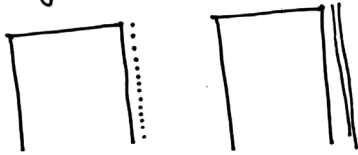
30cm Ruler.

- The markings are not precise and are confusing.



• FEEDBACK ONCE THE SHEET IS FIXED. (CORRECTLY)

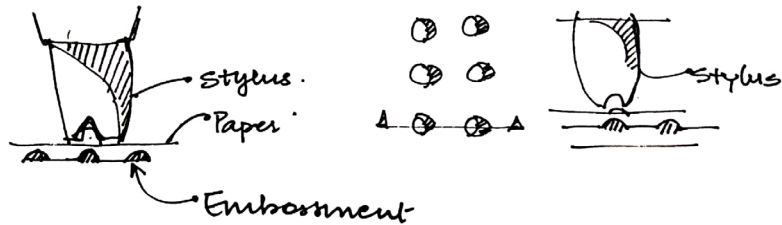
- Sound Feedback
- Punching of Paper (Sound). 
- Snap + fitting into a groove
- Touch Feedback.
- - Alignment of the paper with the edge of the slate.
 - Alignment with a guide.



- Lock To Fix the sheet in place (Touch feedback).

• NEED TO FLIP THE PAPER EVERY-TIME TO DRAW OR WRITE ON THE SAME SHEET.

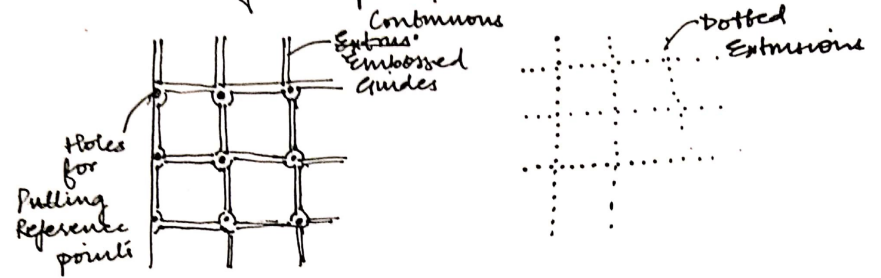
- to be able to write in braille on the same side.



- Inverting the mechanism for the existing, using impression to form figures.

• GRID.

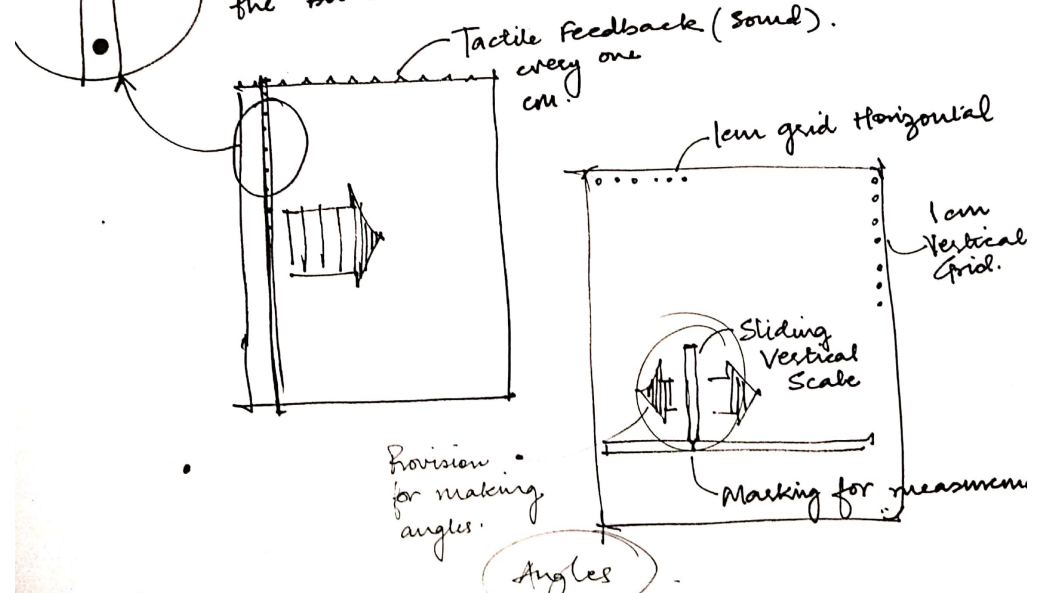
- Giving a more precise 1x1 cm grid
- Ideas for impressions.



- External Grid which can be placed over the slate to act as a grid.

- Using paper with grids (Existing).

- A ruler which can move around on the base slate



7. Mock-ups

For the ideas which were appreciated in the ideation phase, they were tried for their practicality. These ideas were compiled together to form a first prototype of a geometry set.



Fig 67. Protractor Mockup

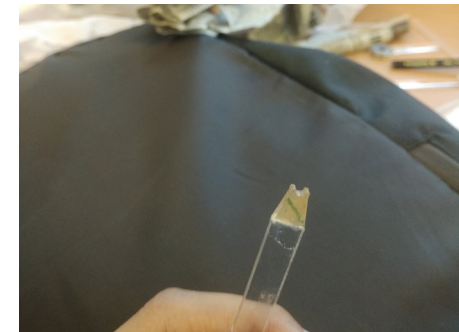


Fig 68. Stylus mockup



Fig 69. Circle master mockup



Fig 70. Stylus mock up



Fig 71. Ruler Ideas

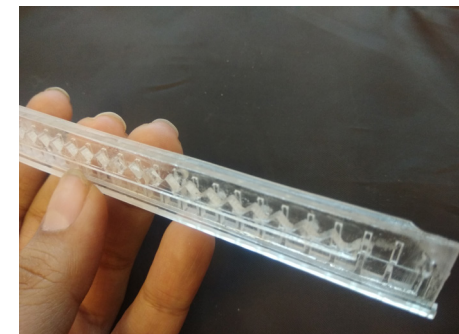


Fig 72. Ruler

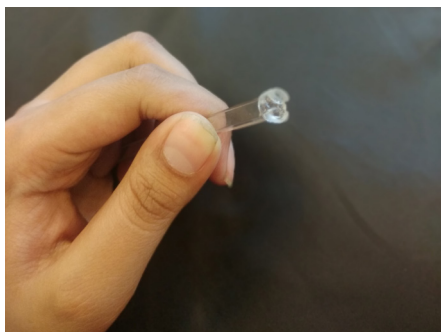


Fig 73. Stylus mockup



Fig 74. Stylus



Fig 75. Stylus



Fig 76. Point markers

8. Concept Prototype I



Fig 77. Prototype of geometry set



Fig 78. The base

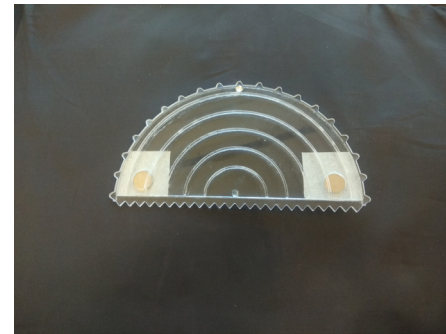
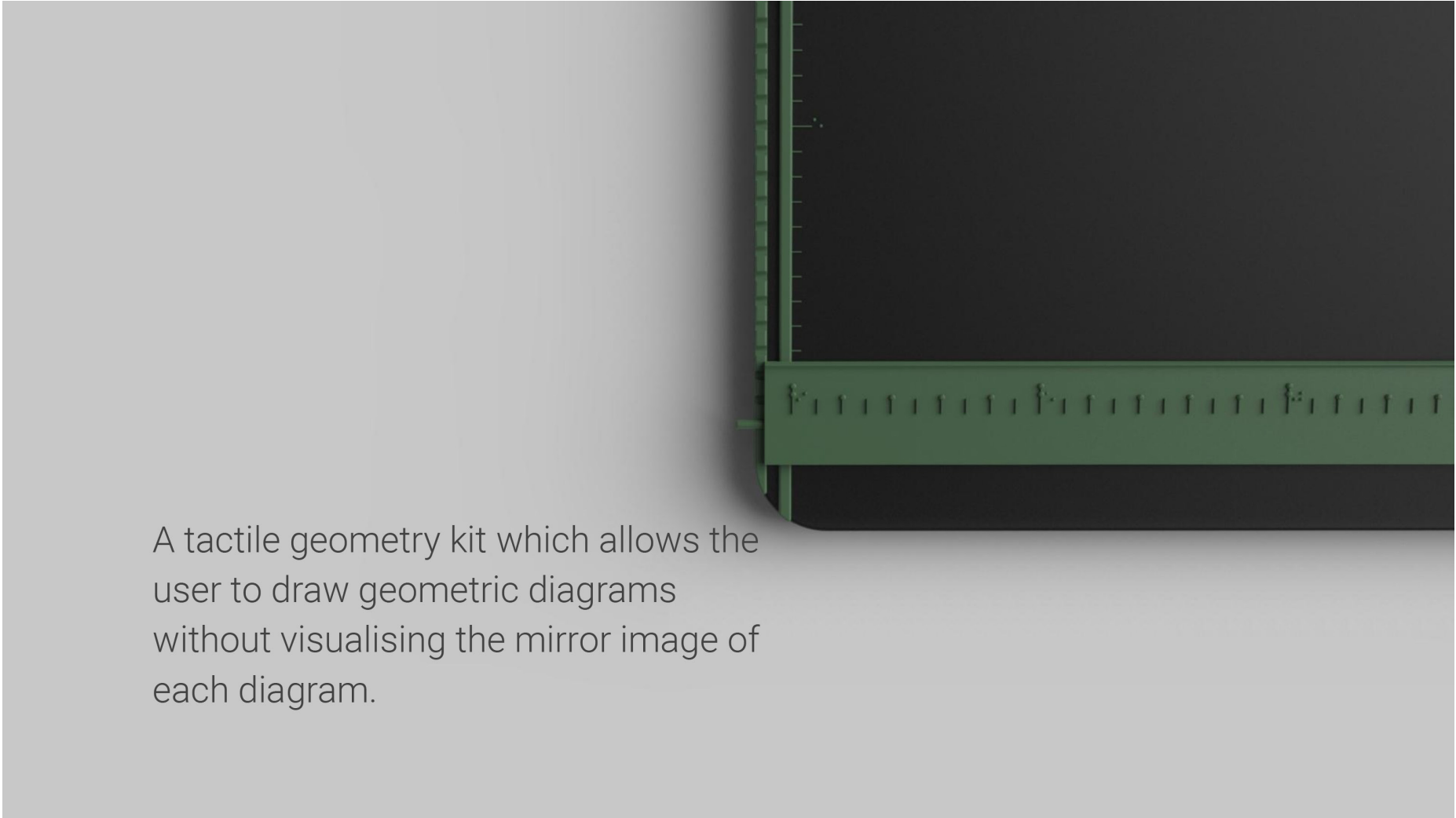


Fig 79. Protractor



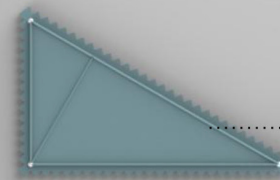
Fig 80. Circle Master

Concept Renderings and details

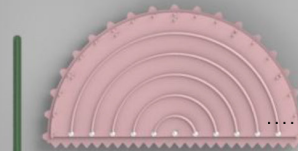


A tactile geometry kit which allows the user to draw geometric diagrams without visualising the mirror image of each diagram.

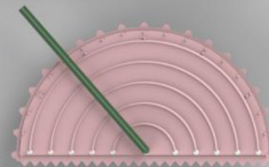
The Base



Set Square



Protractor



Circle Masters

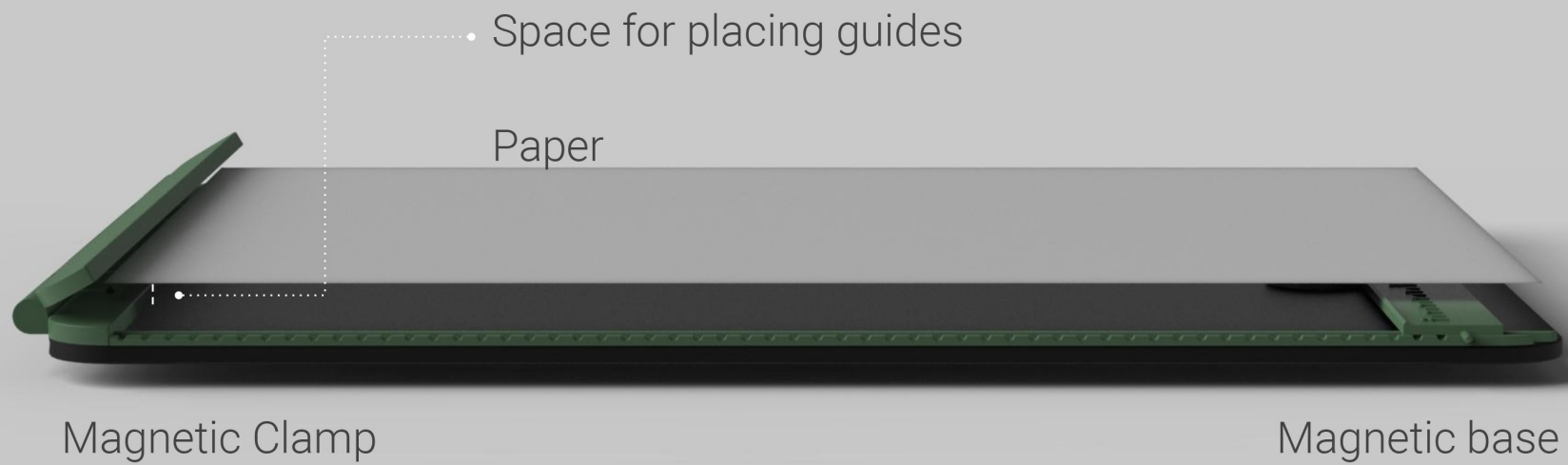


Reference Points



Stylus

Components

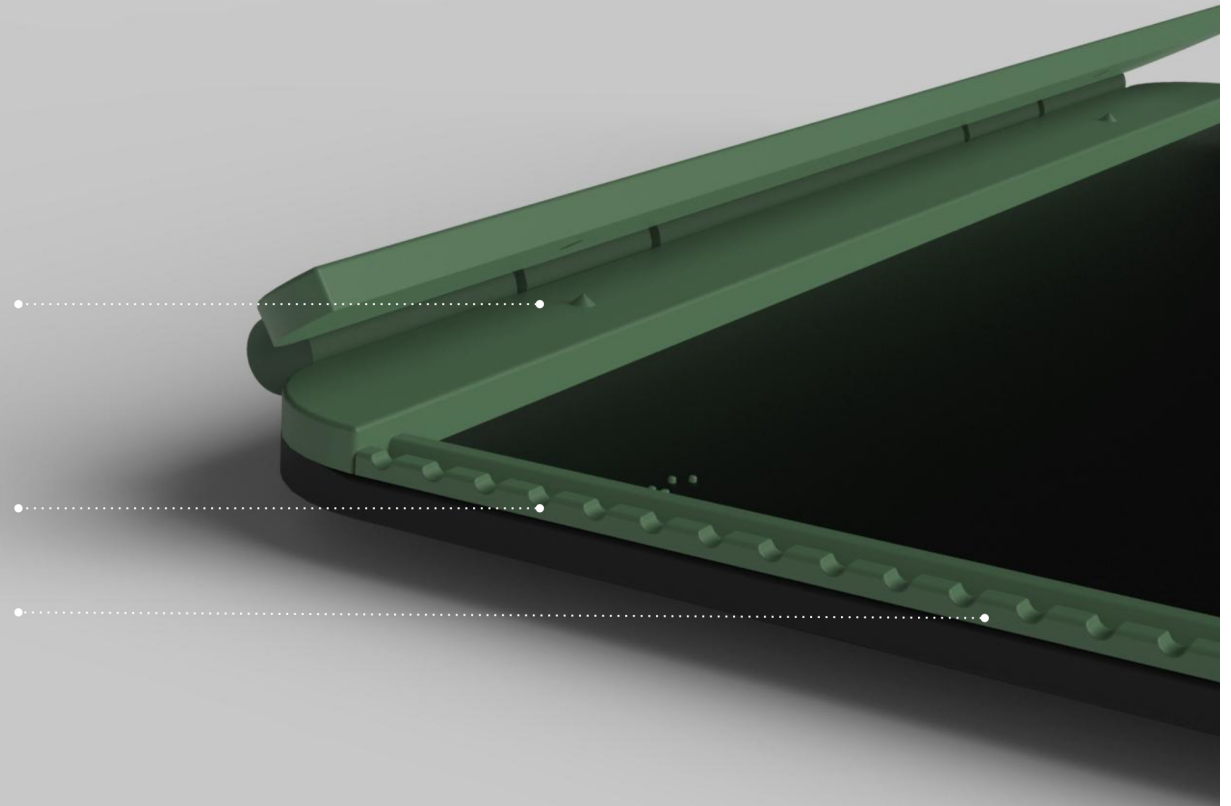


1. The Base

Feature for Punching
the paper

Rail for sliding the ruler

5mm depressions for
tactile feedback



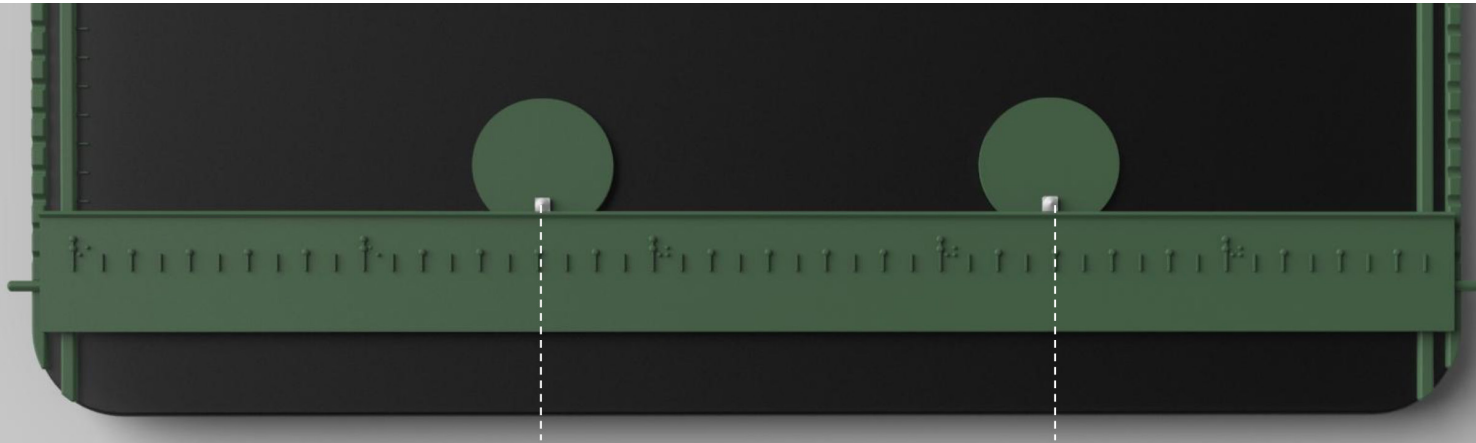
Tactile markings every
5mm on the base

Guide for lines

Feature to adjust in
depressions on the rail
to give tactile feedback

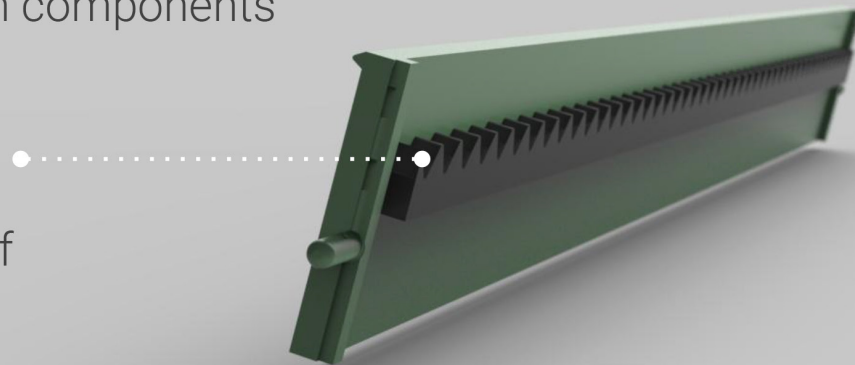
2. Ruler

0.5cm mark, dash
1cm mark, Single dot
5cm mark, Double dot



Grooves are designed in a manner so that the markings align with components

Grooves at the back for other components to align, they also resist the horizontal movement of guides while drawing.



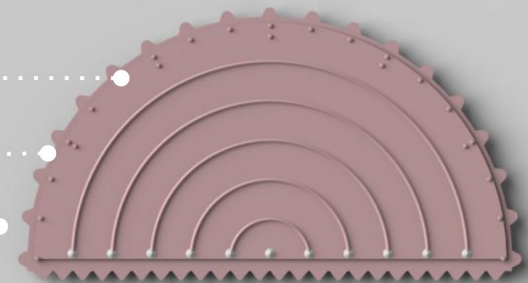
Tactile markings every
10 degrees

Double dots for 0, 30,
60 and 90 degrees

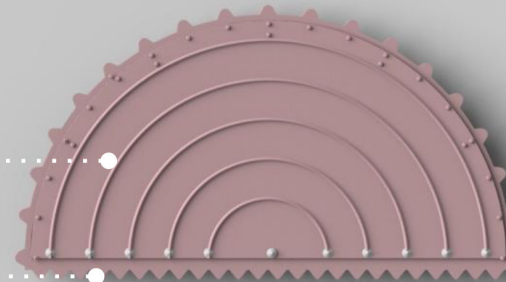
Grooves for aligning
reference points

Guide for making arcs

Grooves for ruler



1, 2, 3, 4, 5cm radius arcs

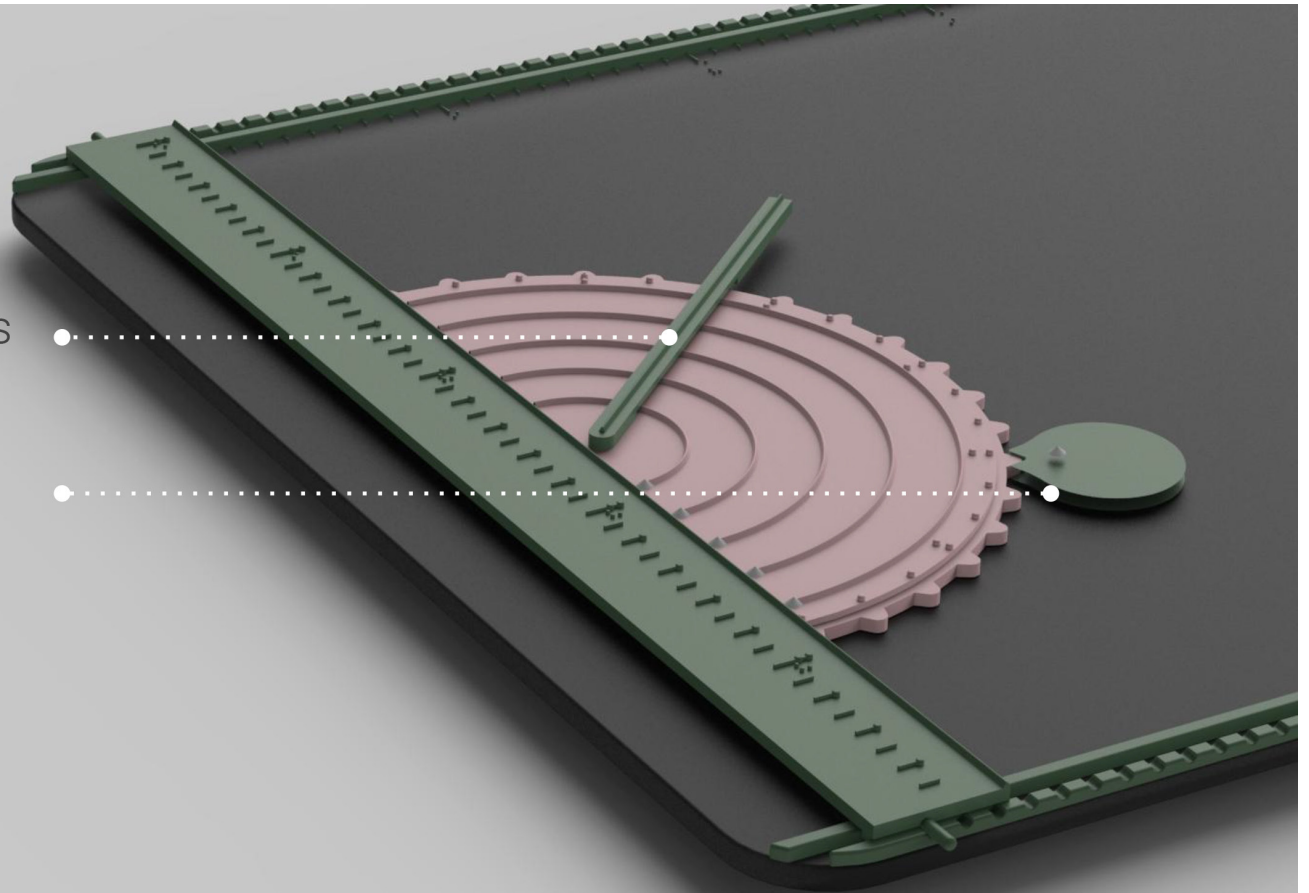


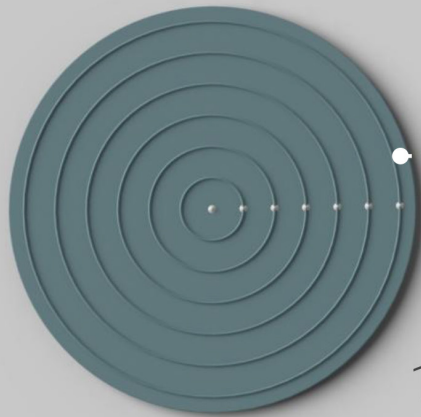
1.5, 2.5, 3.5, 4.5, 5.5 cm radius arcs

3. Protractor

Guide for making angles

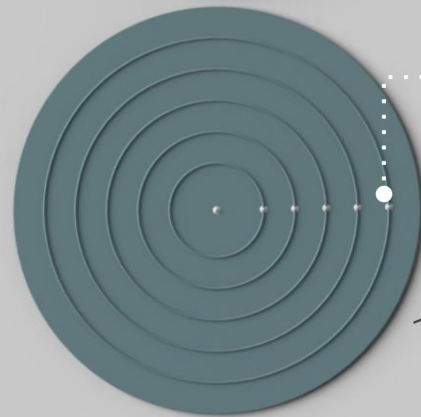
Reference Point





1, 2, 3, 4, 5 cm radius circles

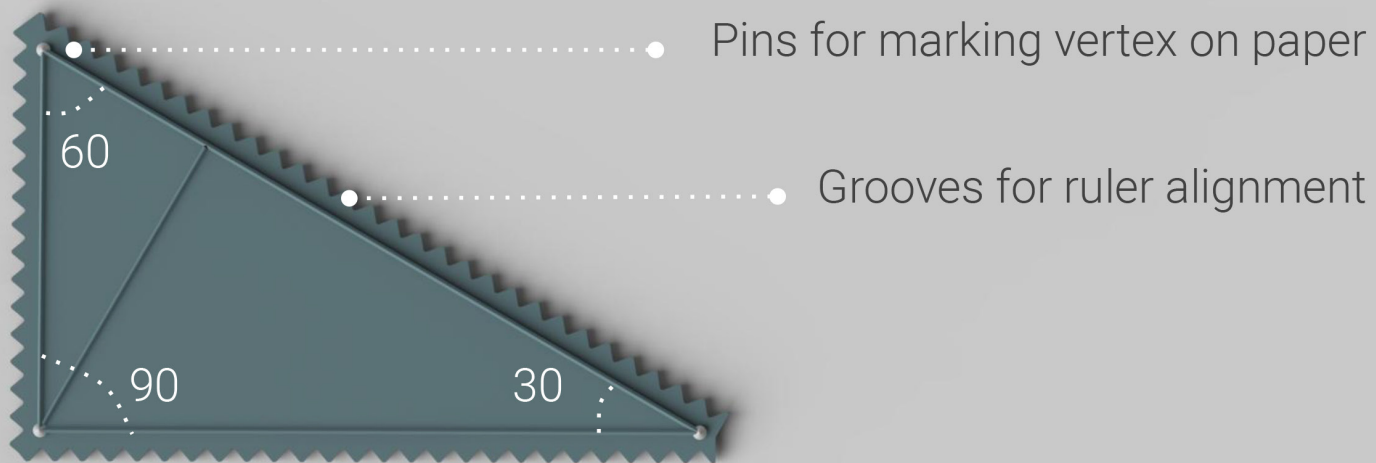
Embossed guides for making
circles on paper



1.5, 2.5, 3.5, 4.5, 5.5 cm radius circles

Pins for marking points on paper
and also depicting the centre

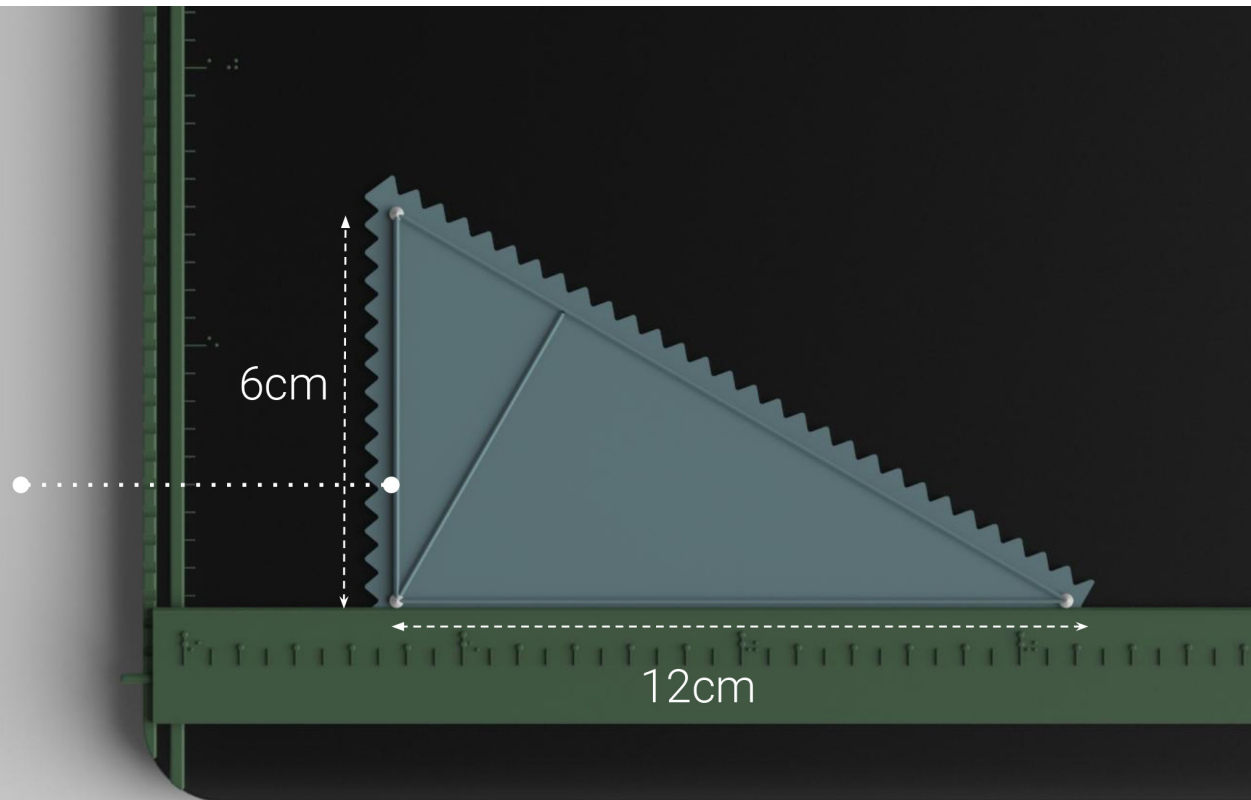
4. Circle Master

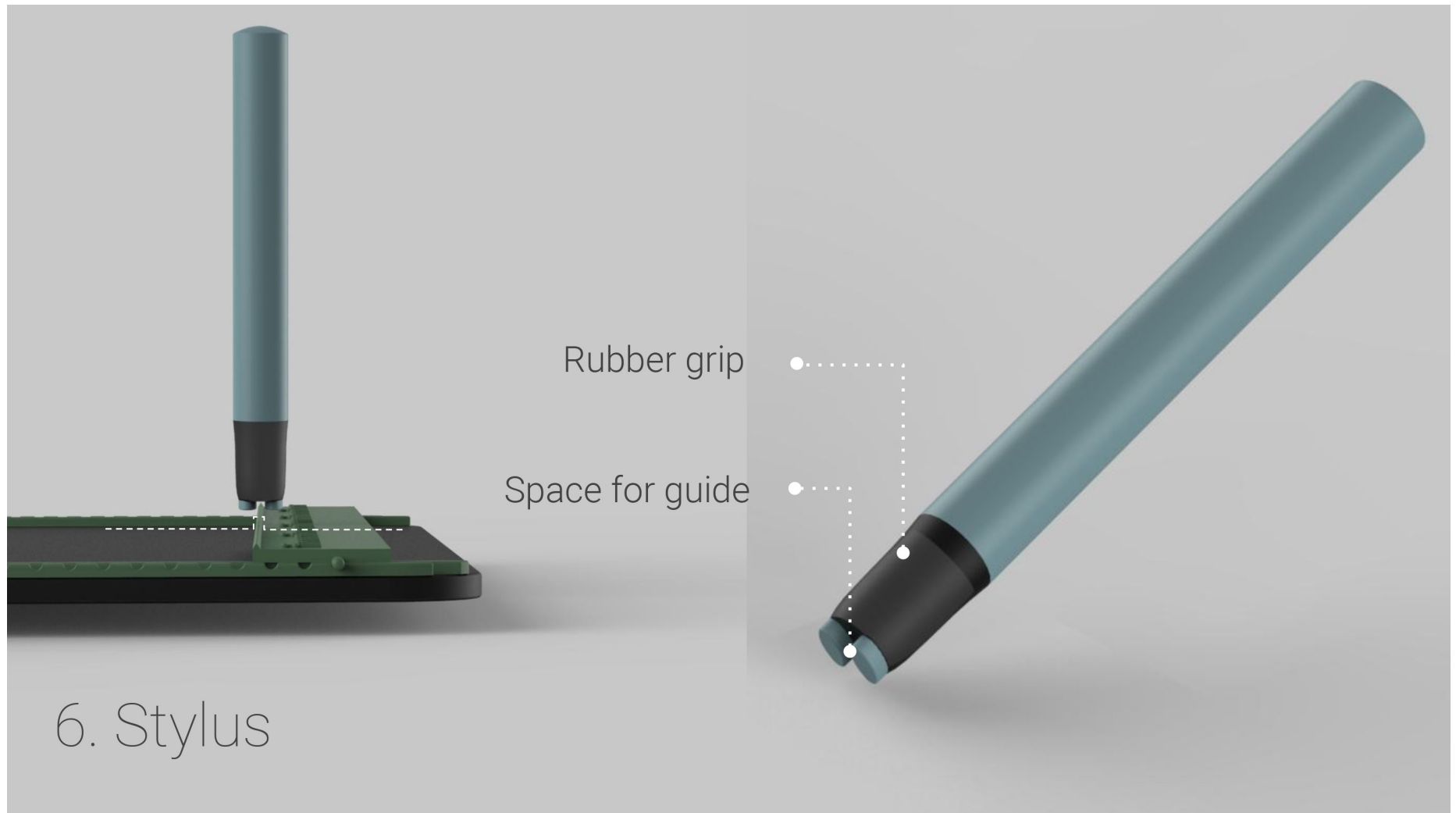


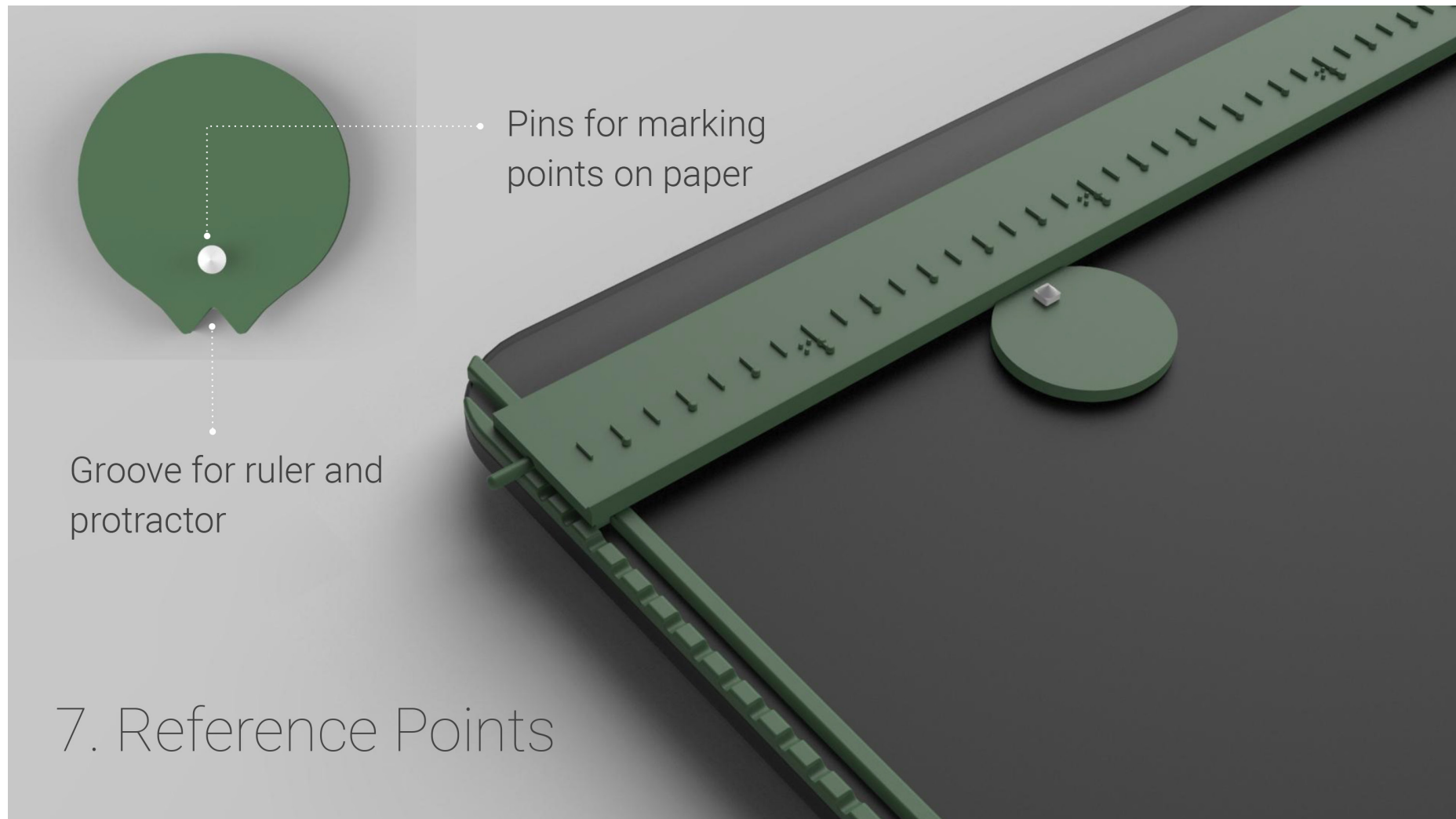
5. Set Square

For making quick angles of
90, 60, 45 and 30 degrees

Guide for making angles







1st Prototype



Fig 81. Prototype of geometry set



Fig 82. The base

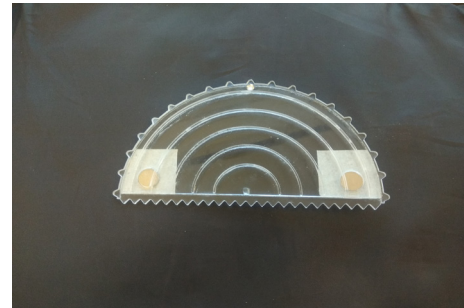


Fig 83. Protractor

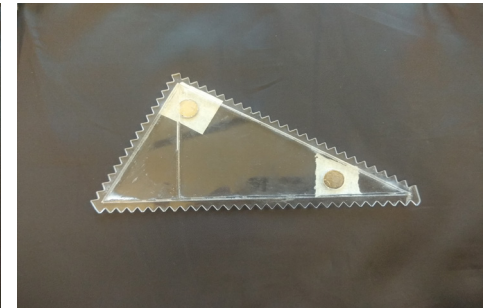


Fig 84. Set Square



Fig 85. Point Markers

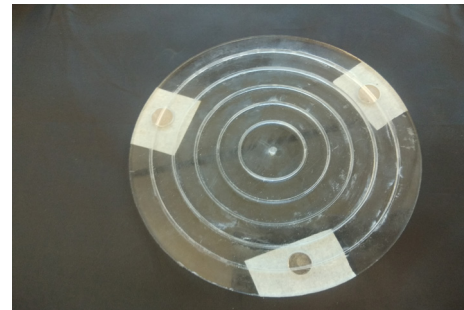


Fig 86. Circle Master



Fig 87. Stylus

Feedback

After the first prototype was completed, a blind-fold test was conducted to get feedback on the design.

During this experiment multiple tasks were given to the user which were, *Constructing a line segment*, *Constructing an angle bisector* and *Constructing a triangle*. The observations were noted down during this experiment and inferences were drawn from that.

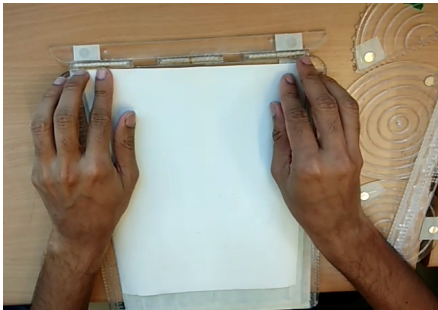


Fig 88. Fixing the paper

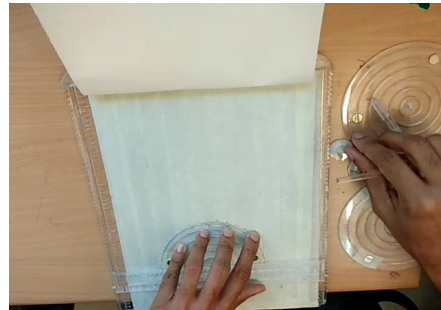


Fig 89. Drawing arcs



Fig 90. Drawing angles

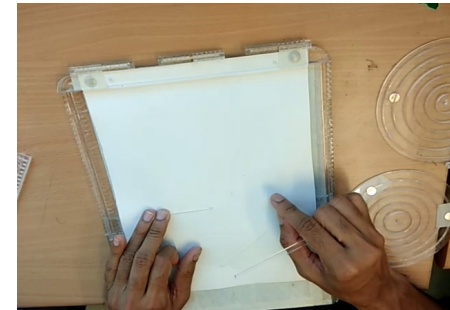


Fig 91. Drawing parallel lines

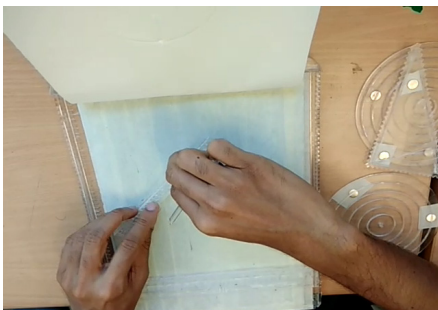


Fig 92. Constructing a triangle

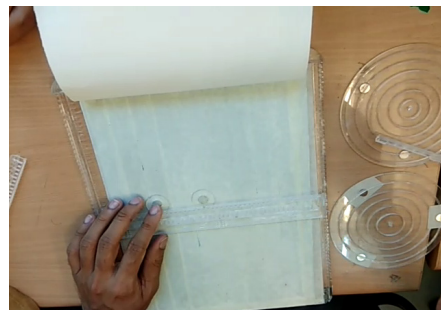


Fig 93. Line segment



Fig 94. Fixing the Point markers

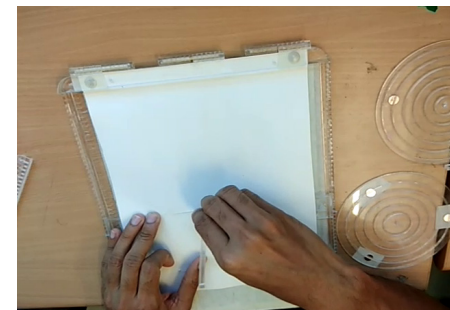


Fig 95. Creating an Emboss

Observation

- Constant need to hold the paper back while fixing the guides, which kept one hand occupied at all times.
- Not possible to make angles like 5,15,20,25.
- Difficulty in fixing the angle guide.
- Tearing of paper while making smaller curves.
- Difficult to locate and place tools once in use.
- The depth of the point markers and their depth led in tearing of paper while drawing lines.
- The stylus was difficult to grip,
- It was difficult to pick the tools back up again once placed on the base due to high magnetic strength.
- The parallel ruler did not provide enough tactile feedback.

Inferences

- Need for an intervention to hold the paper back while placing the guides.
- Detailed marking on protractor is required.
- A reduction in the depth of the point markers is required since it is leading in the tearing of paper.
- A more fluent movement and a better feedback required for the movement of parallel ruler.
- A better intervention required for the joining the point markers to draw straight lines.
- Need to organise the tools for easy finding and placing of the tools.
- Reduction in the magnetic power of the tools is required.
- Requirement for a better grip of the stylus.
- Need for a good packaging of the kit to increase the portability.
- An addition of writing in Braille.

Further Improvements

Packaging

Making it portable

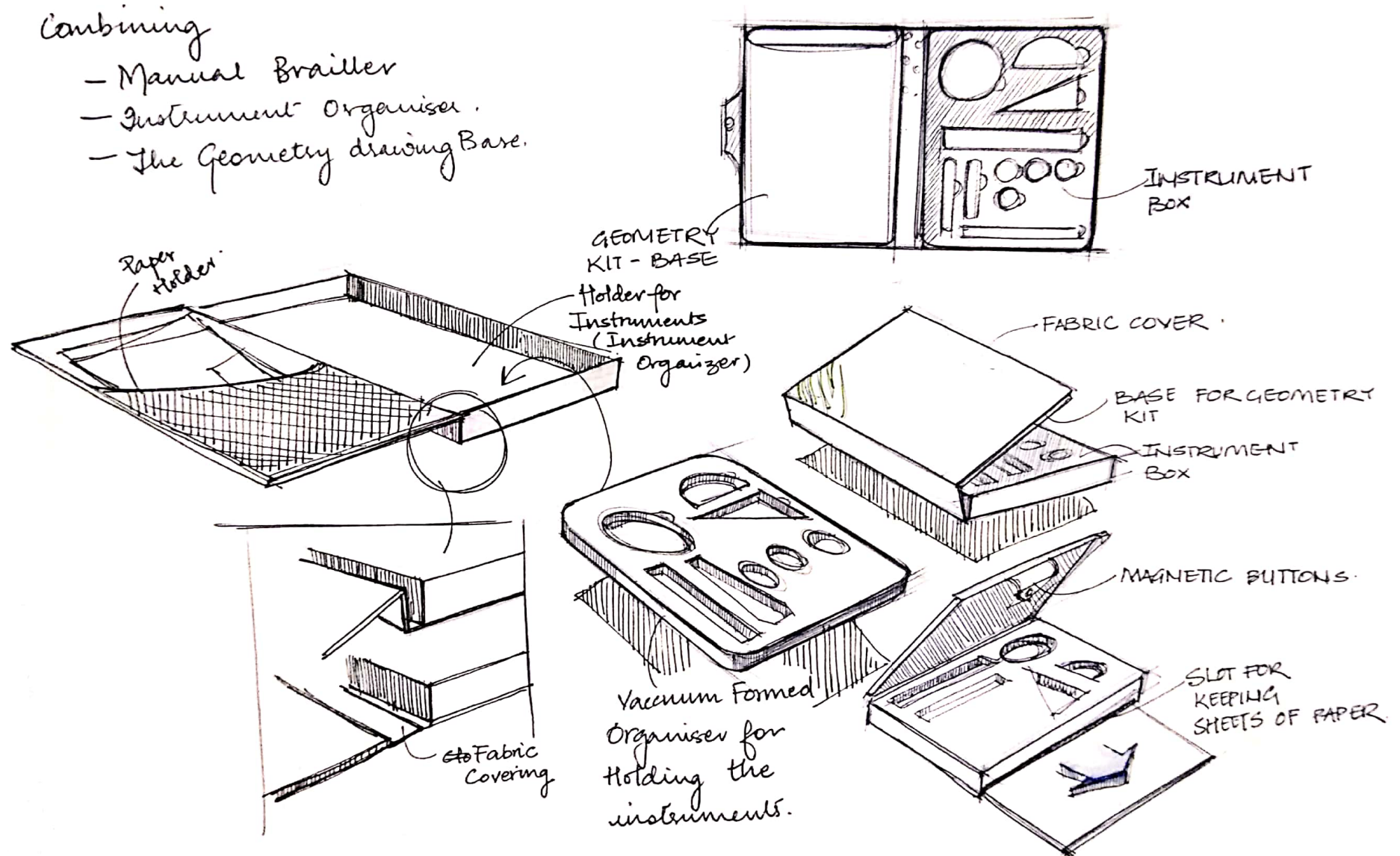
Collecting more feedback

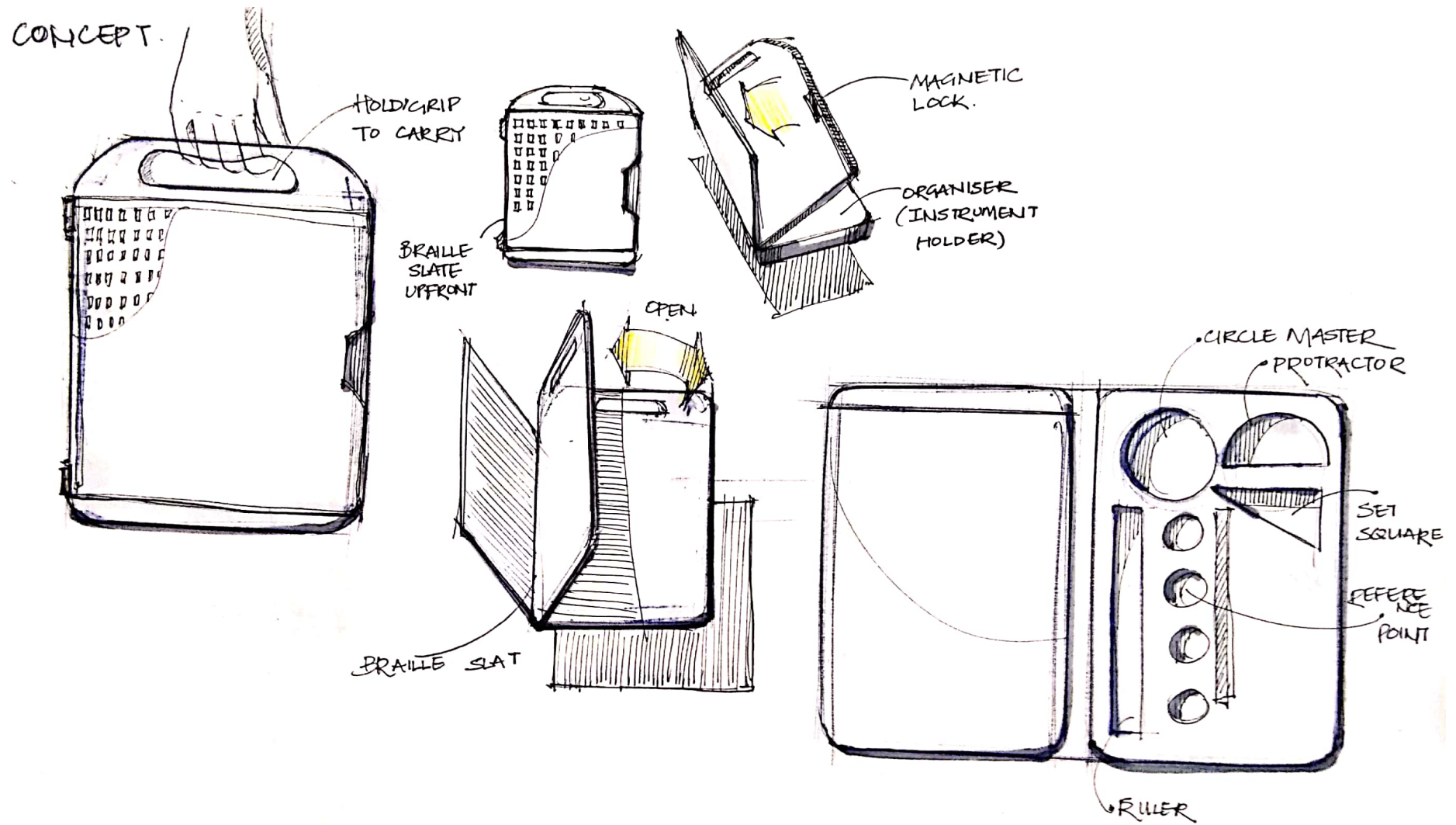


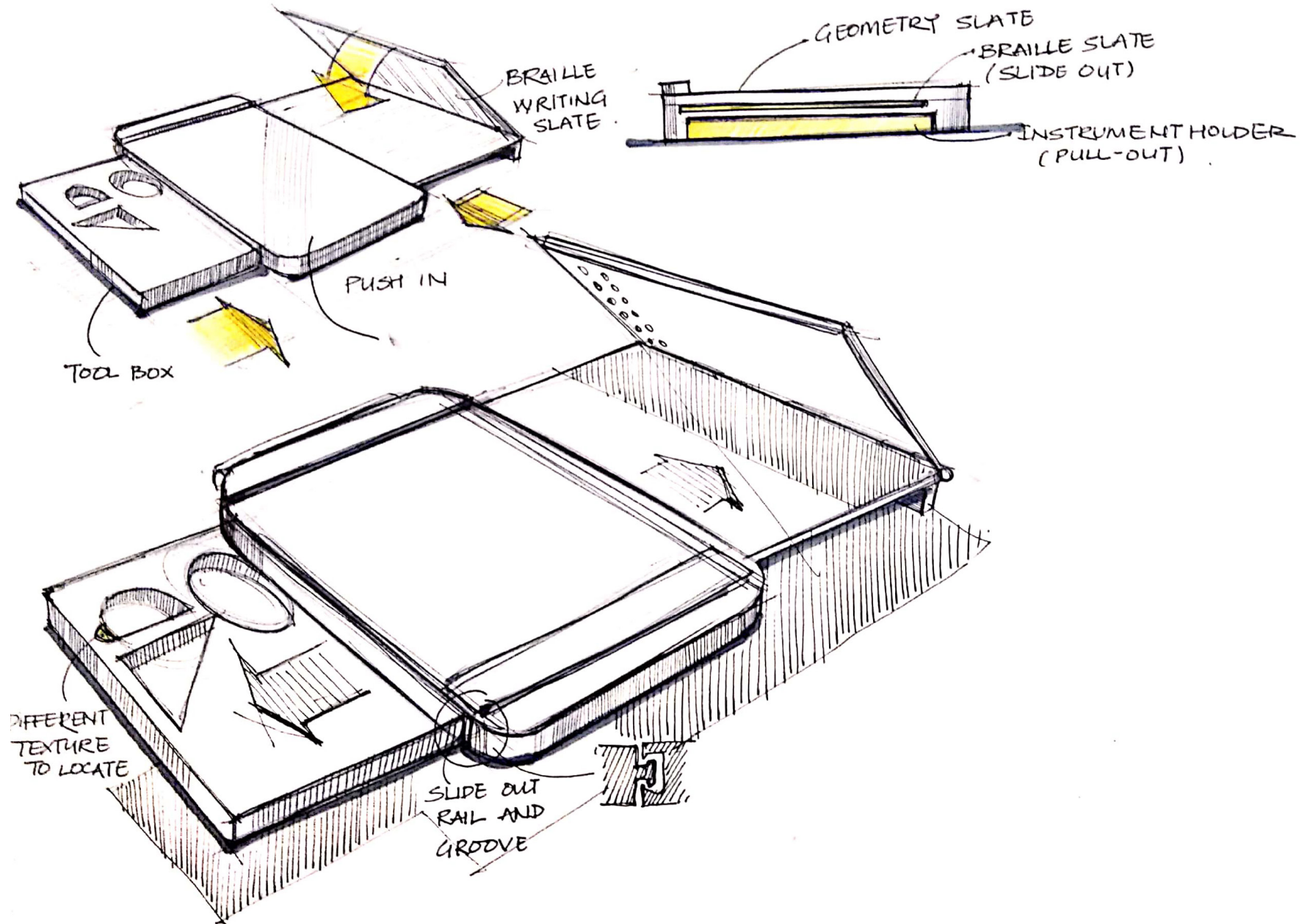
Further Refinements

Combining

- Manual Braille
- Instrument Organiser.
- The Geometry drawing Base.



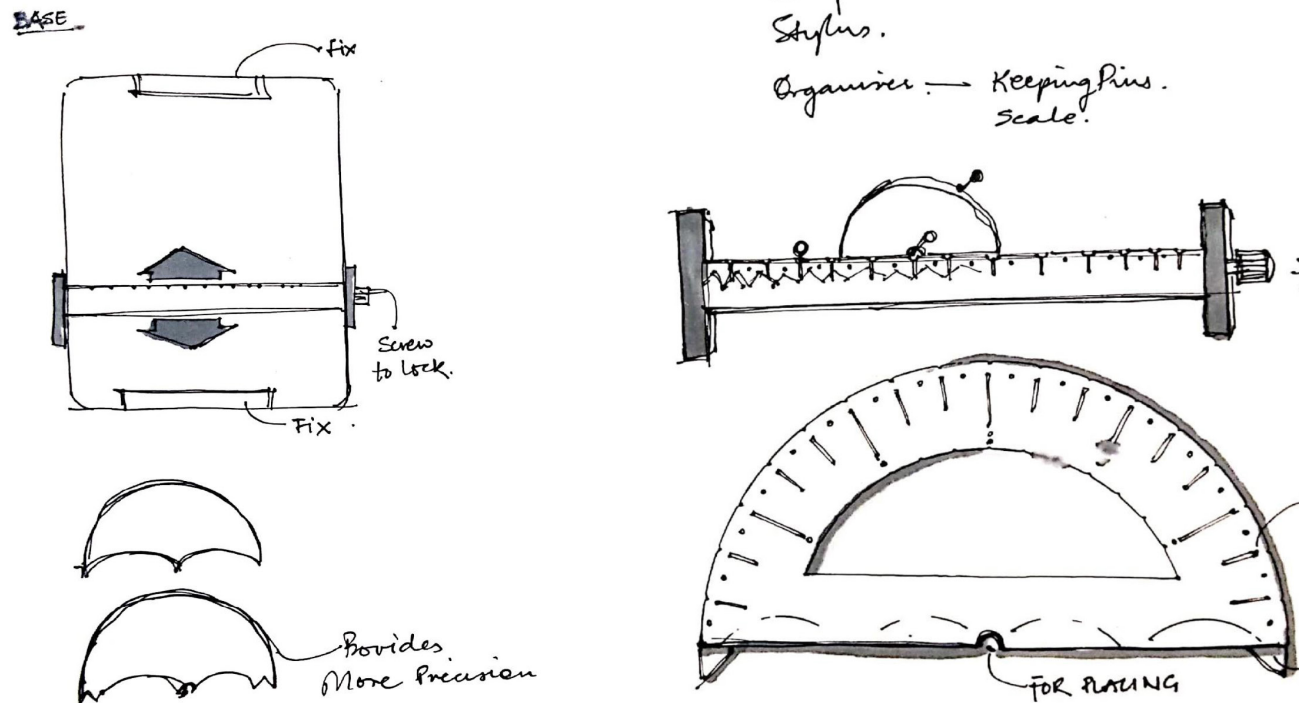


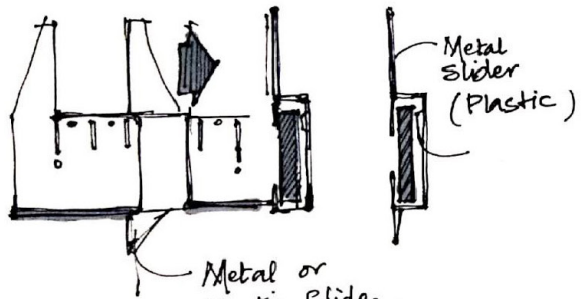


Feedback from XRCVC

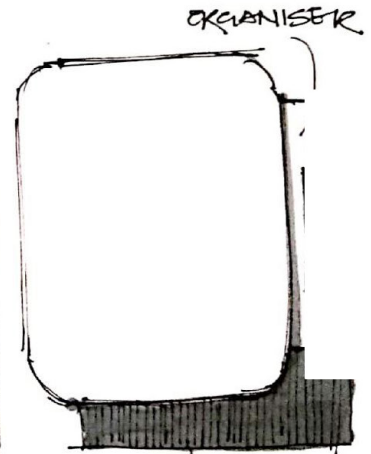
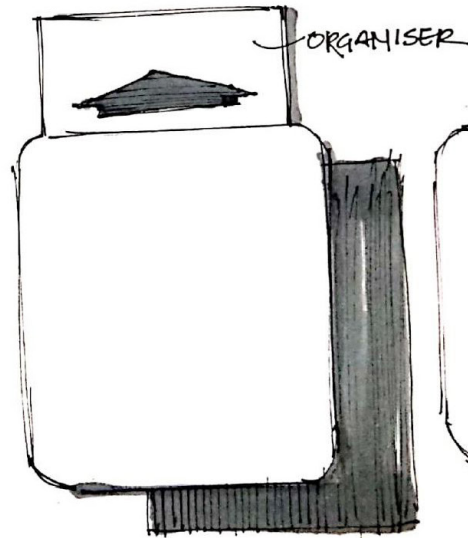
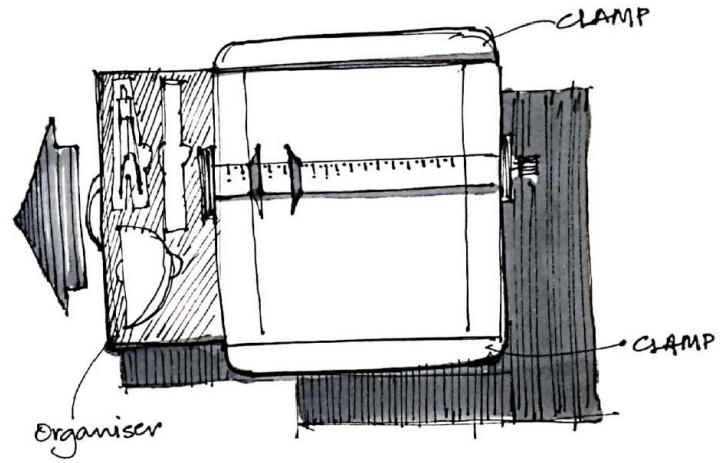
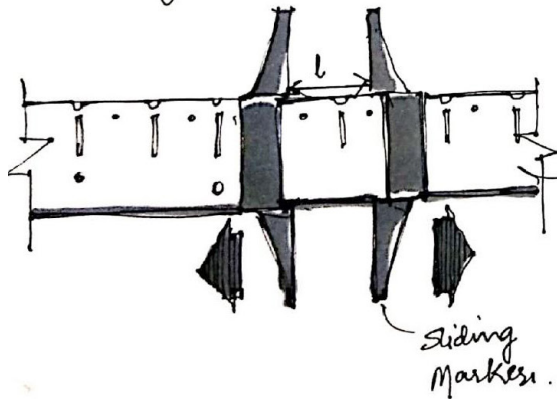
- The use of tactile geometry kit with embossed accessories was not preferred as it was extremely difficult for students to learn.
- The use of direct drawing was preferred.
- The idea of locking and aligning the instruments parallel to the base was appreciated.
- More precision required for Protractor

Refinements

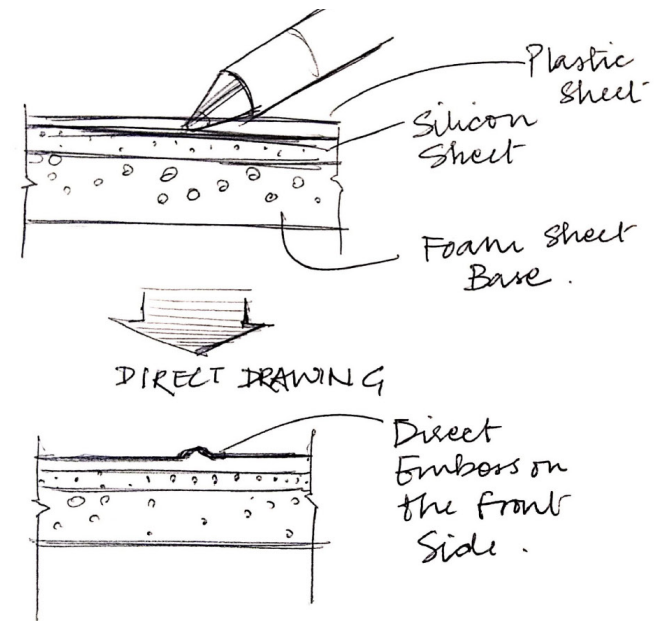
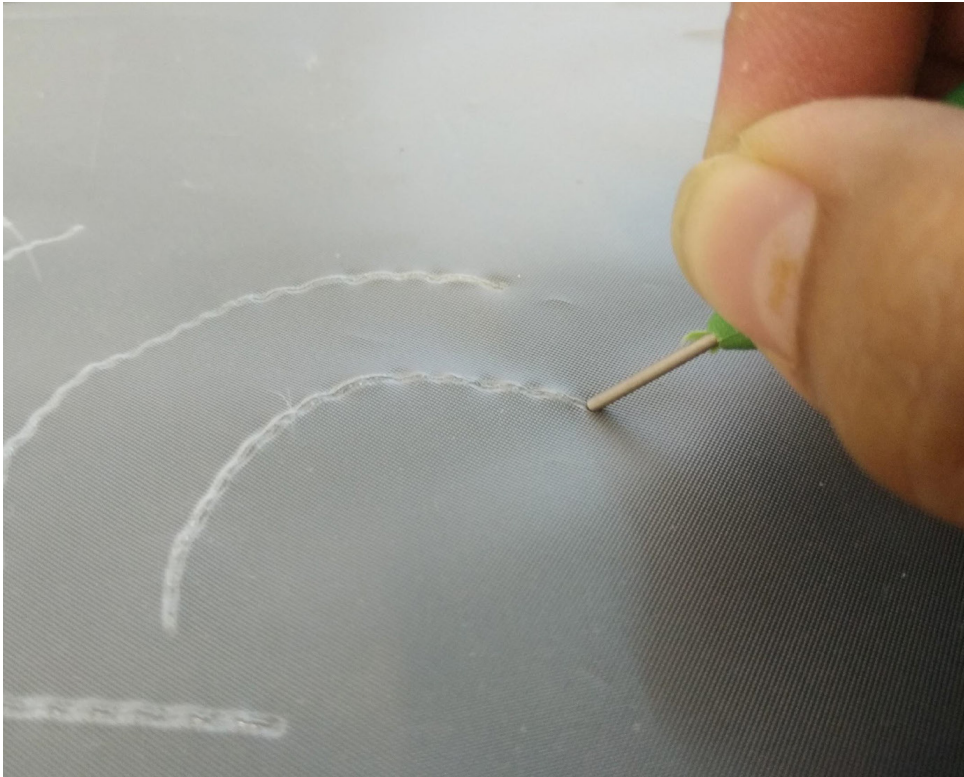




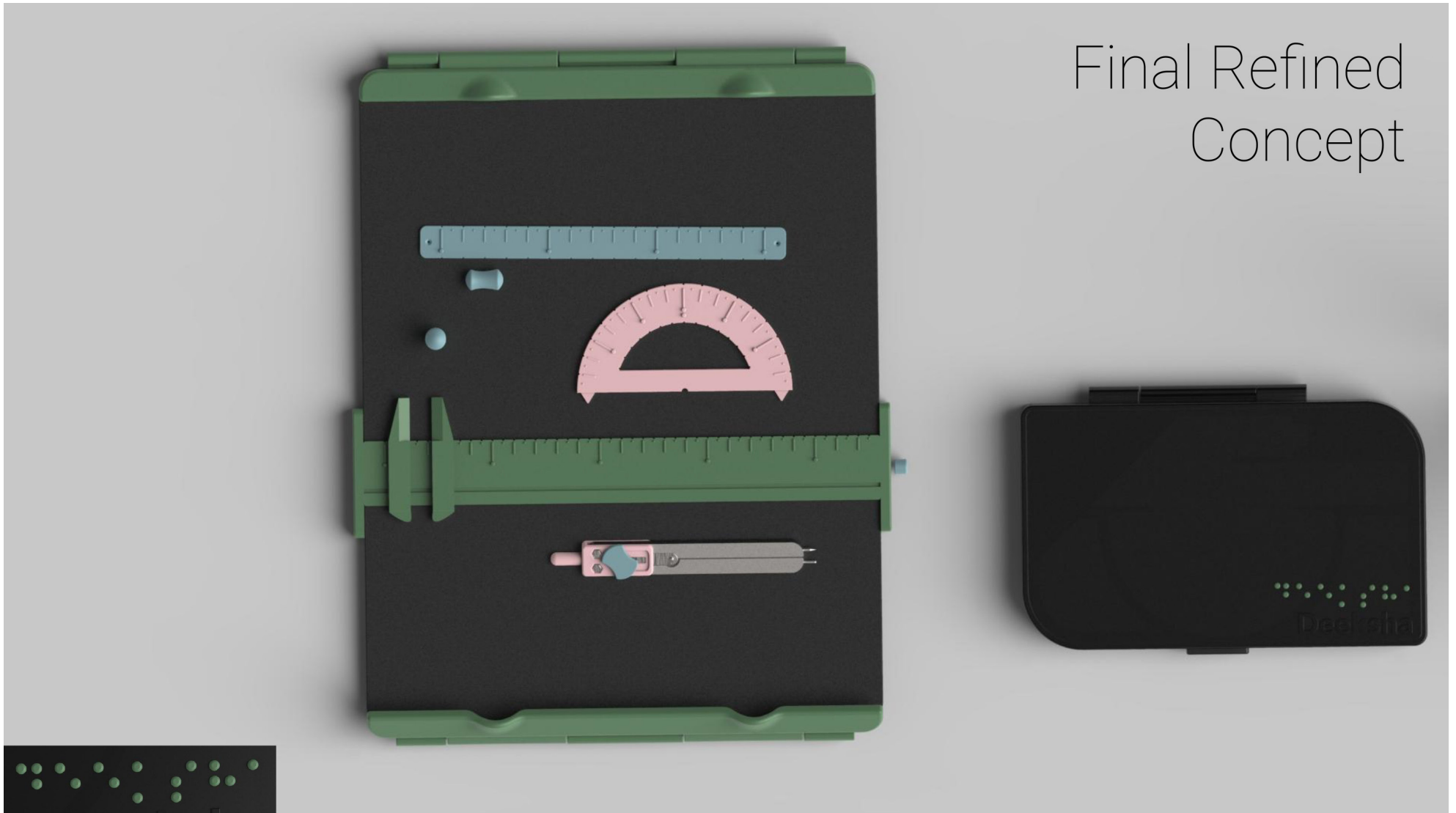
- Used for measurement and for drawing line segments.



9. Final Design

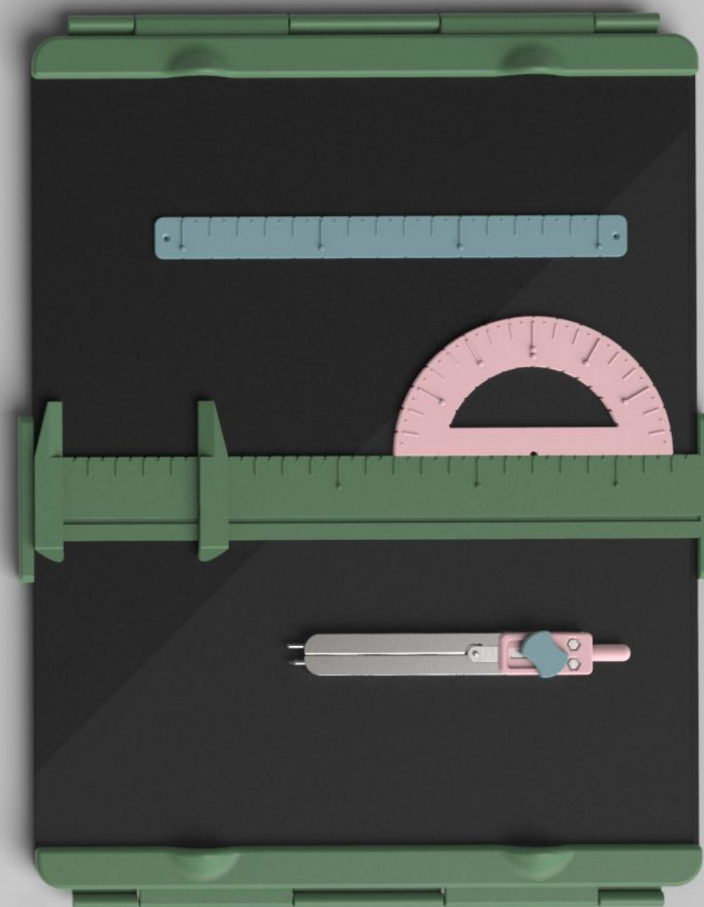


Final Refined Concept



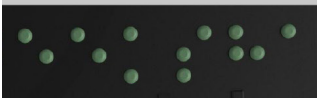
Components

1. Silicon Base
2. Parallel Ruler with sliders
3. 15cm Ruler
4. Protractor
5. Compass
6. Organiser
7. Pins



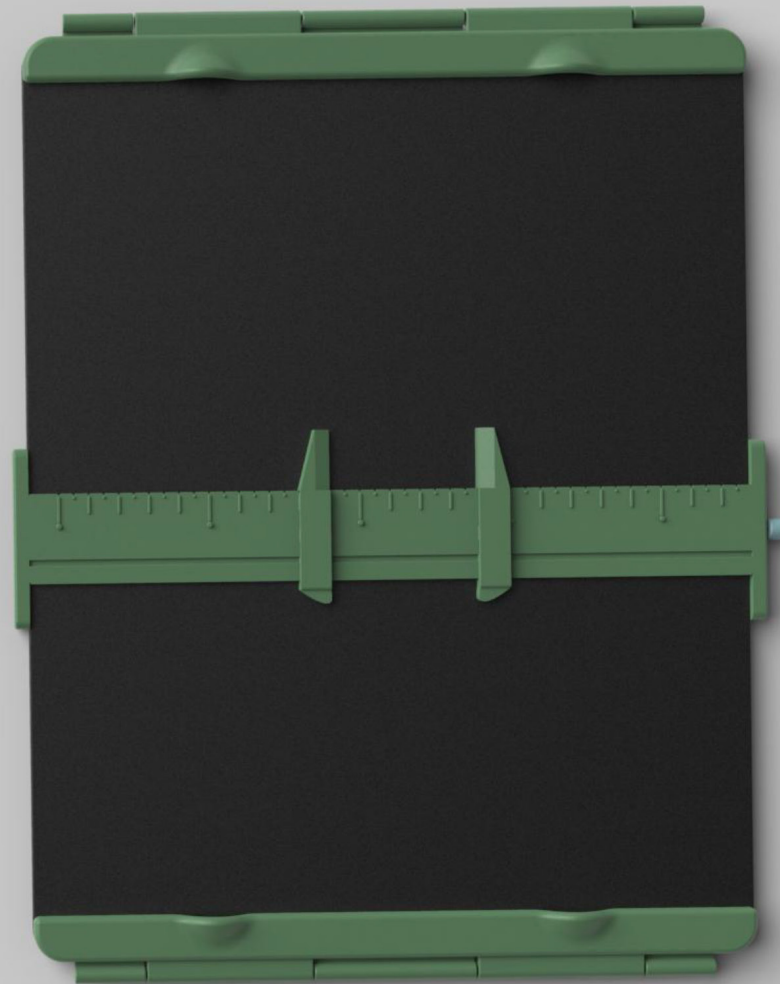
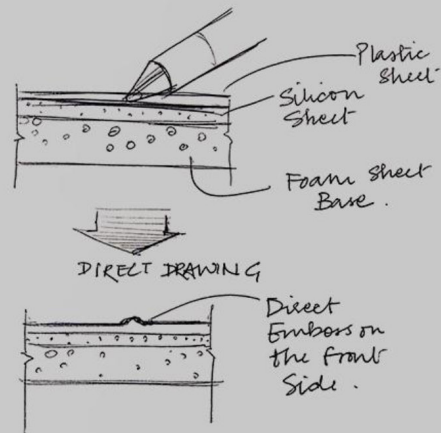


A direct drawing geometry kit with least number of elements, closest to the experience of a sighted student. It uses the braille stylus or any other daily use pen to create emboss



Silicon Base

The base layer is of silicon which provides an elastic base, further down it is foam, which provides the stability to the pins.





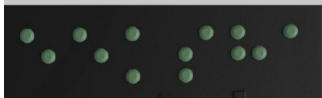
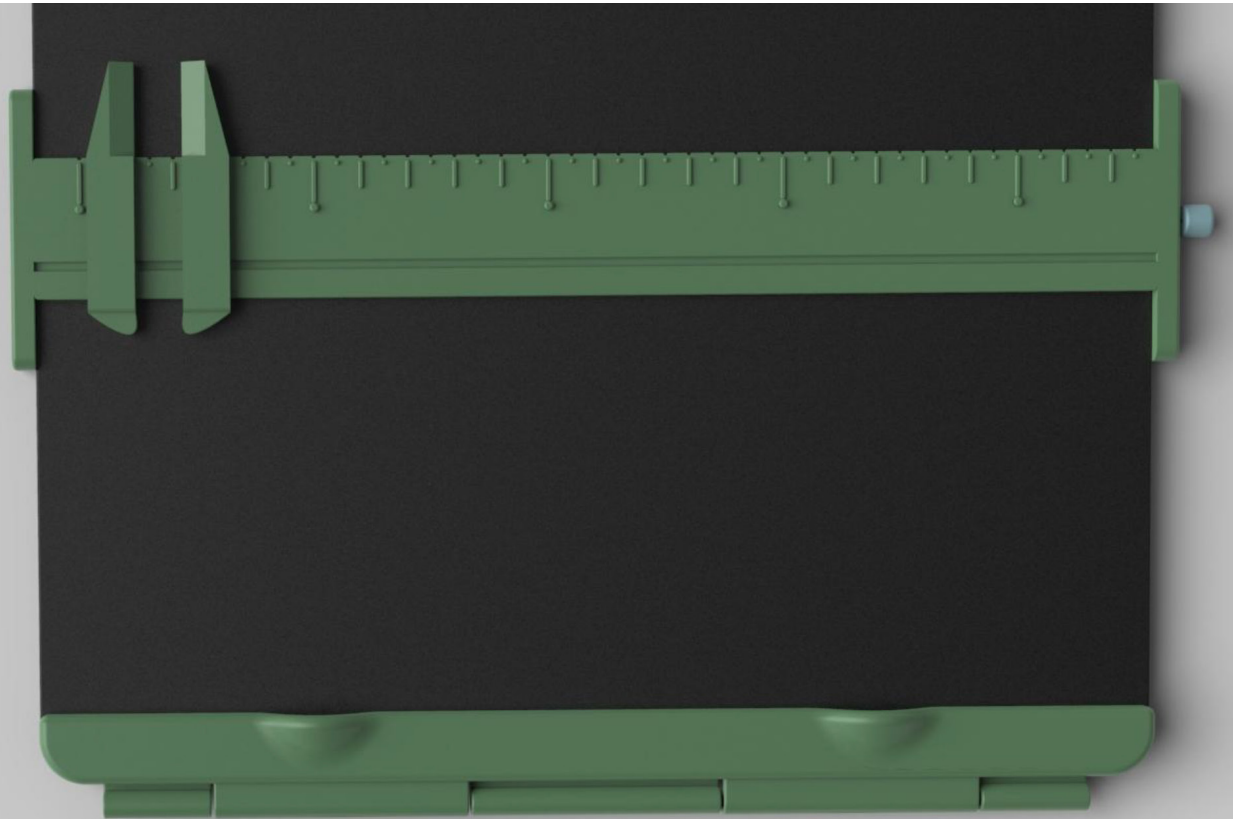
Silicon Base

Magnetic clamps on both edge to stop sliding of paper.
Bumps on top to provide ease of grip

Parallel Ruler with sliders

The parallel Ruler with grooves underneath provides alignment and stability to other tools

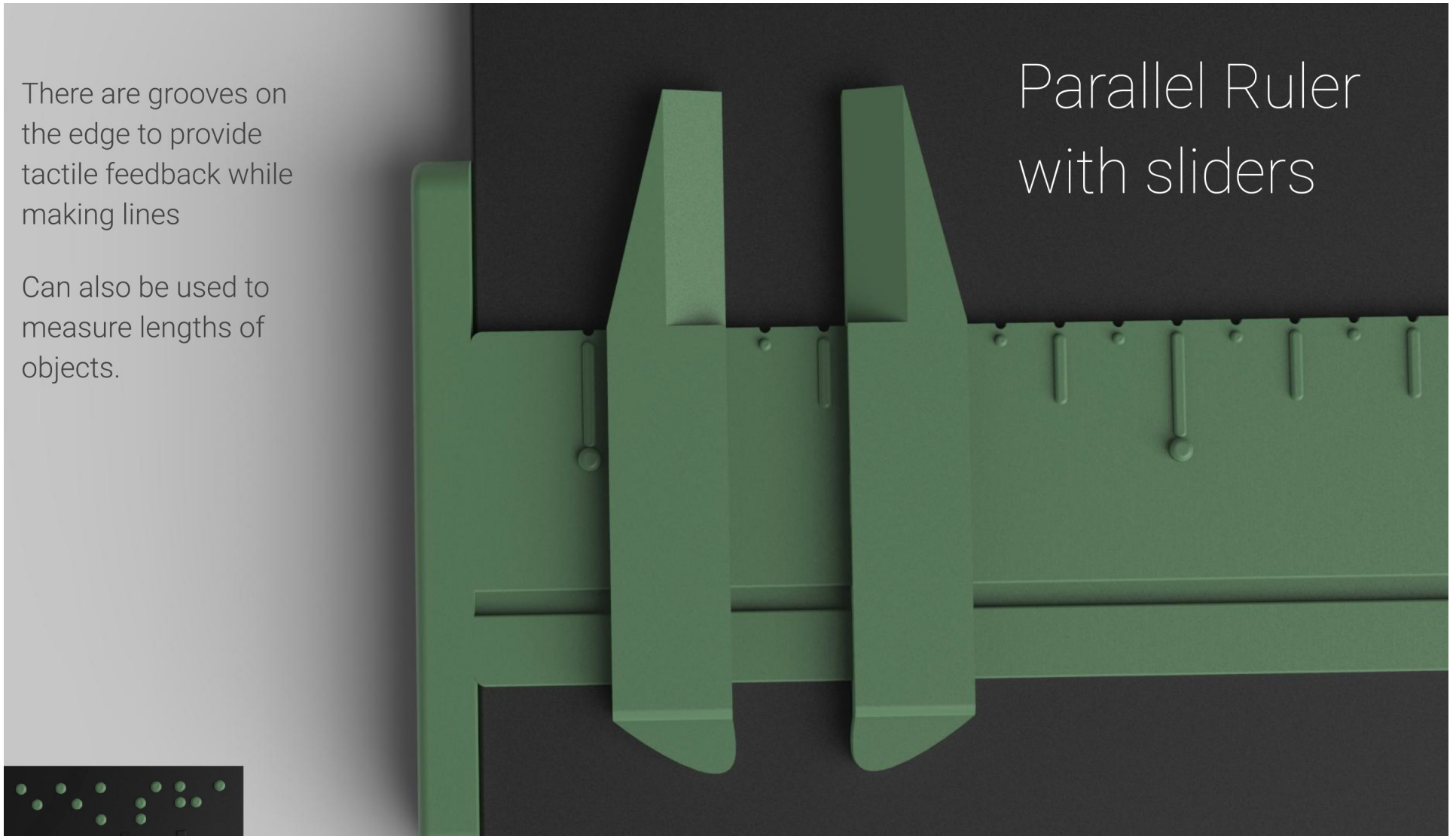
Screw to lock position

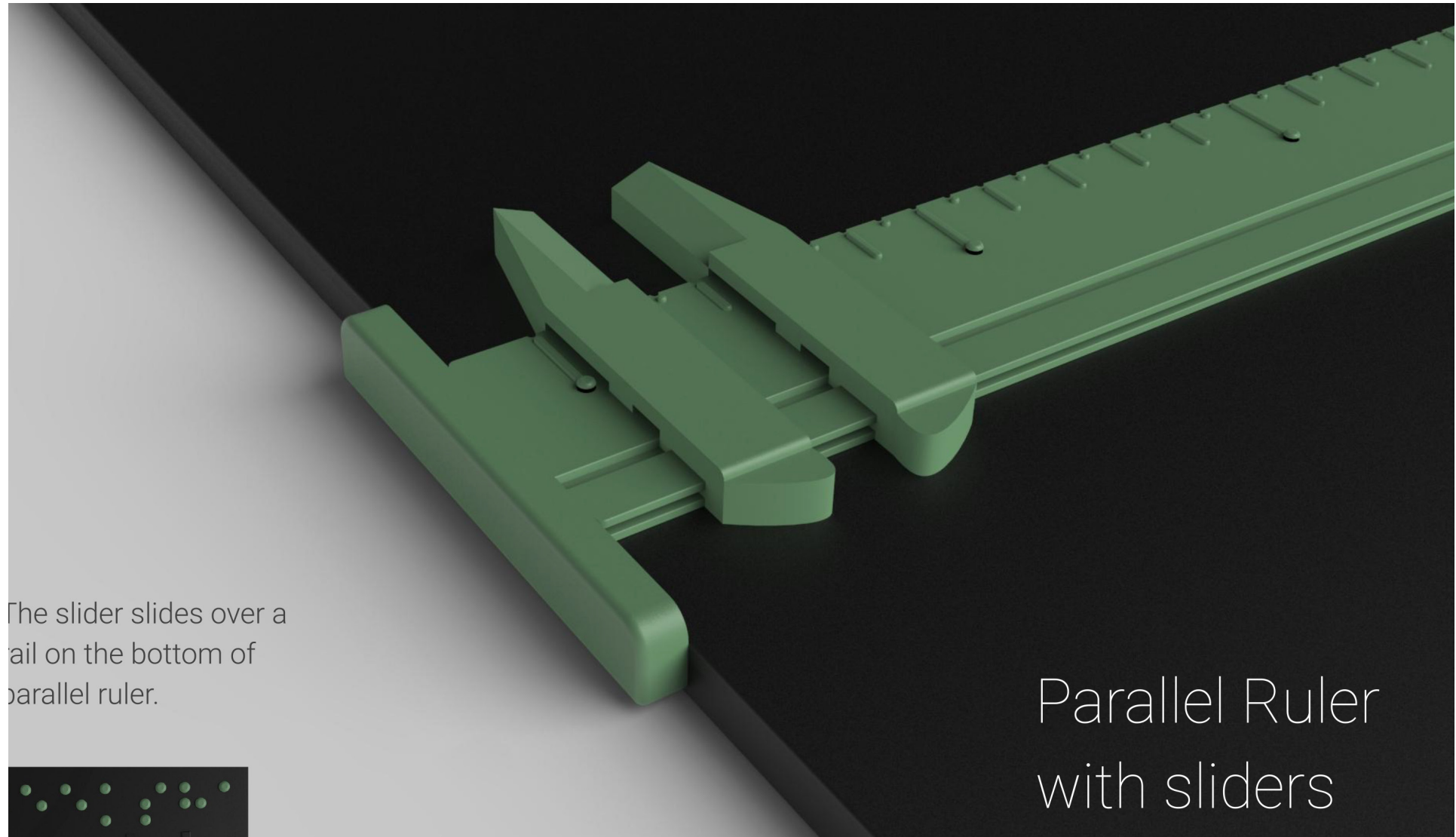


There are grooves on the edge to provide tactile feedback while making lines

Can also be used to measure lengths of objects.

Parallel Ruler with sliders





The slider slides over a
rail on the bottom of
parallel ruler.

Parallel Ruler
with sliders

15cm Ruler

Grooves on the edge
every 5mm

Holes to insert pins on
the ends to fix it on
base.

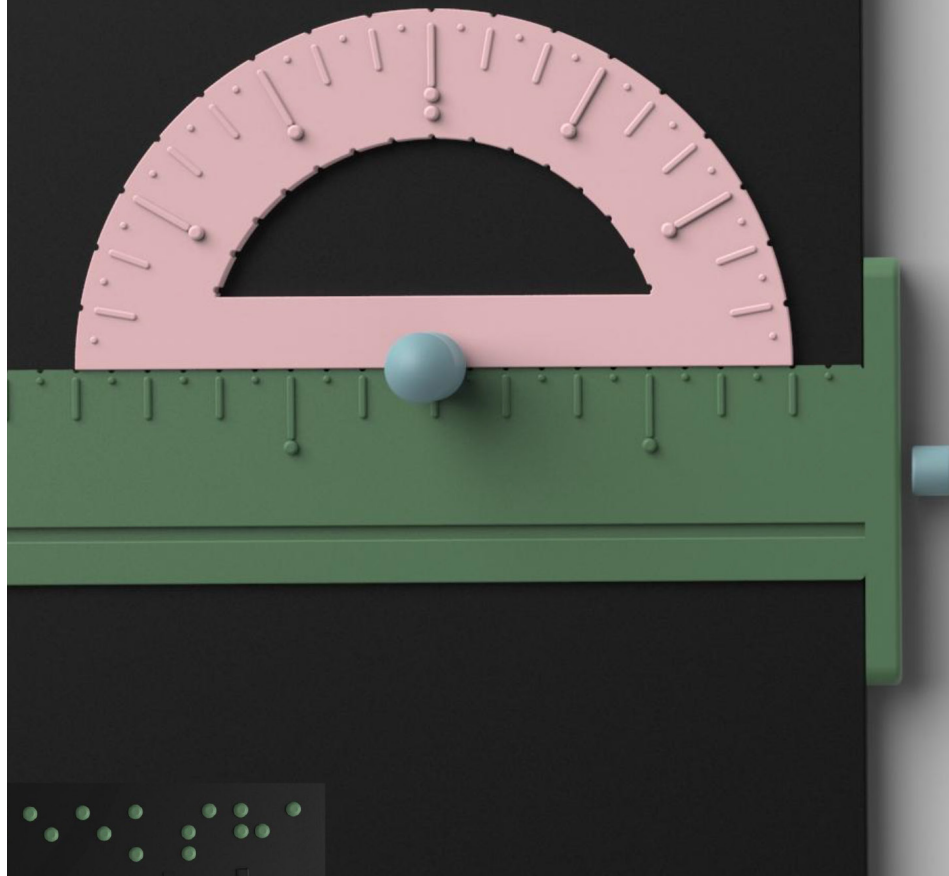


15cm Ruler

Standard
measurements



Protractor



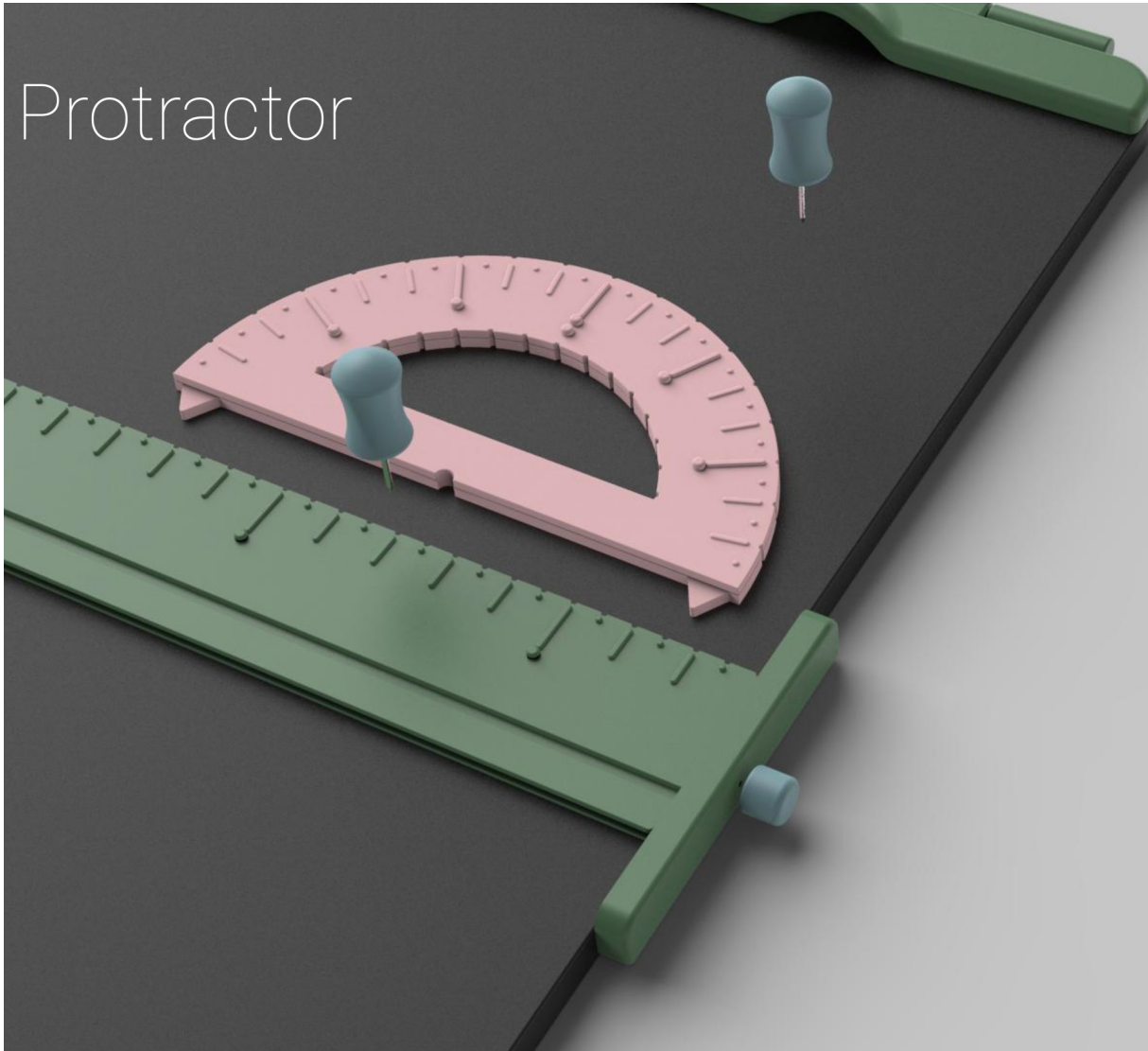
Standard measurements

Hole in the centre to put the pin to
locate vertex

Very Precise

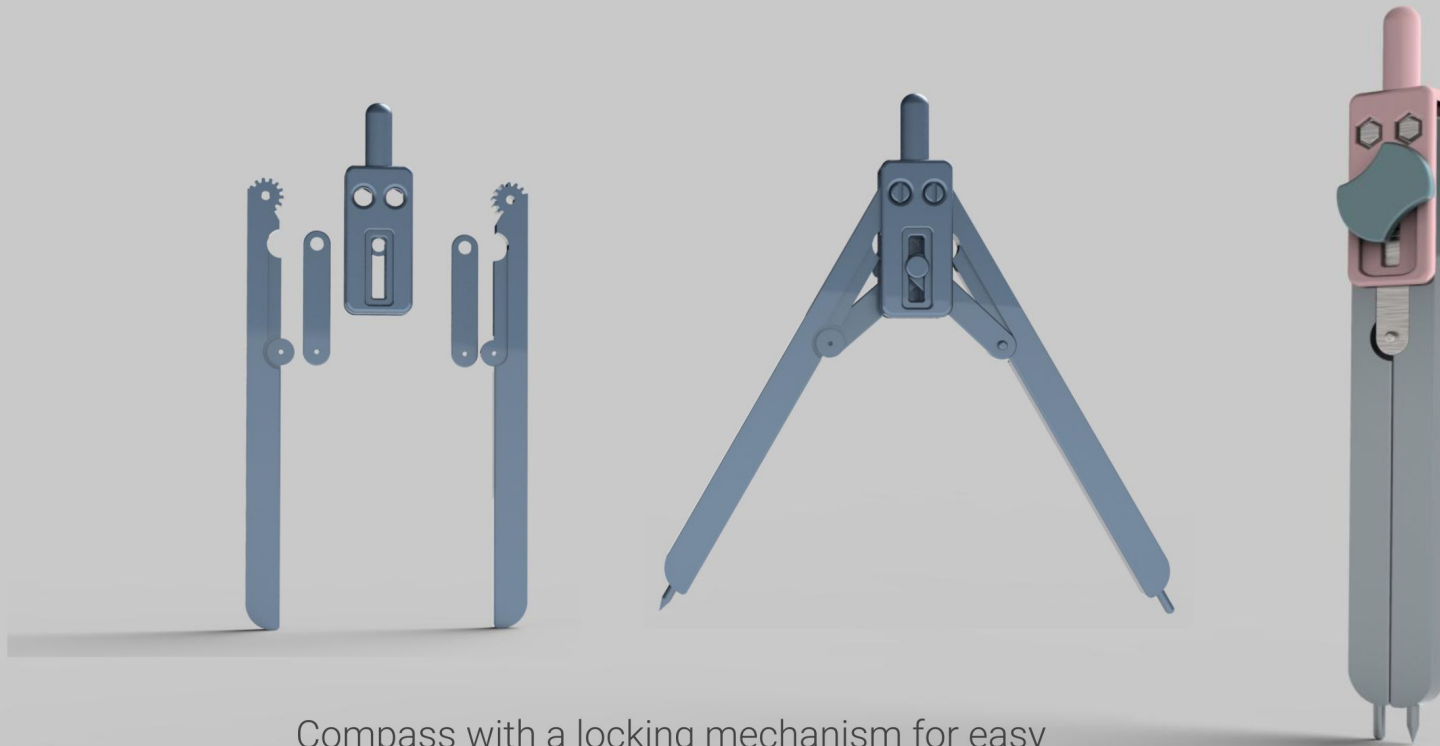
Helps making Angles

Protractor



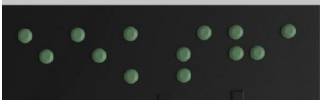
Triangular extrusion the end
which fits in the grooves in
the parallel ruler.

Compass



Compass with a locking mechanism for easy adjustment of arc length.

Metal Legs and Plastic cap



10. Conclusion

This project began with a simple intention to help visually challenged children. But as I dug deeper into the topic, I became aware of the needs and requirements of visually challenged people and that there are multiple design opportunities yet to be explored.

The project also sensitised me towards universal design.

Geometry is an essential subject taught to most students as it forms the basis of the understanding of shapes and form. Teaching geometry to blind students is going redundant in multiple Blind schools due to the sole reason of lack of communication between teachers and students. Design can help bridge this gap.

Hence, there is a need for design interventions in this direction to enable the visually challenged children to achieve the future they deserve.

11. References

Online References

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[2] "Cognitive toys for visually disabled children"
Name of student -Vivek G Menon

[3] Impact of visual impairment on development available on <https://www.tsbvi.edu/the-impact-of-visual-impairment-on-development>
Blindness: Types, Causes, and Symptoms. 2016. Blindness: Types, Causes, and Symptoms. [ONLINE] Available at: <http://www.healthline.com/symptom/blindness>

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[6] <https://www.nabindia.org/history-and-milestones/> as accessed on 26-5-2019

[9] <http://www.happyhomeschoolfortheblind.org> as accessed on 27-05-2019

http://www.happyhomeschoolfortheblind.org/gallery_1.html

[10] NCERT mathematics Syllabus

Reports

Title - "Cognitive toys for visually disabled children"
Name of student -Vivek G Menon Guide: Prof. Ravi Poovaiah

Title - "Design of teaching-learning aids for blind children"
Name of student -PATRIC JOHN Guide - Prof : R. Sandesh

Title - "Learning Aid For Visually Impaired Children",
Name of student - Priyanka Chavan. Guide - Prof : Mandar Rane.

Title - "Playing kit for Visually Impaired children",
Name of student - Sanjay B Nair. Guide - Prof : R. Sandesh. year -2010

Title - "Vocational/Educational Aids for the visually handicapped",
Name of student - Sanjay T Koli. Guide - Prof : Mohan Bhandari. year -1991