

P2 Project

Spirometer for kids

Project Guide : Prof.Purba Joshy

Submitted by:

Athira E

Roll no: 216130003


Approval form

This is to certify that the Industrial Design Project entitled “Designing a spirometer for children who are suffering from Asthma, COPD, bronchitis and other respiratory diseases for the age group of (5-10) Year old” by Athira E is approved for partial fulfillment for the Master of Design degree.

Prof . Purba Joshi [Project Guide] : 

Signature of the Chair Person: 

Signature of the Internal Examiner: 

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Declaration form

I declare that this written report accurately expresses my ideas in my own words, and that where others' ideas or words have been used, I have properly cited and referenced the original sources. I also certify that I followed all academic honesty and integrity rules and did not falsify, misunderstand, or create any idea, data, facts, or source in my work. I understand that any breach of the foregoing will result in disciplinary action by the Institute as well as criminal action from the source from whom sufficient authorization was not obtained or was incorrectly referenced.

Signature:

Name of the student: Athira E

Roll no: 216130003

Date: 11/11/2022

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Abstract

COPD (chronic obstructive pulmonary disease) is a leading cause of illness and mortality worldwide. According to WHO estimates, 65 million individuals suffer from moderate to severe COPD. COPD killed about 3 million people in 2005, accounting for 5% of all deaths worldwide, and it is expected to be the third greatest cause of death by 2030. Developing countries are rapidly changing. Socioeconomic development, industrialization, urbanization, changing age structures, and changing lifestyles have resulted in a growing burden of non communicable diseases(NCD) like COPD in the countries. India contributes a considerable and growing proportion of COPD mortality, which is considered to be among the highest in the world, with more than 64.7 estimated age-standardized death rates per 100,000 people in both sexes. Crude estimates suggest there are 50 million COPD patients in India. Among which the disease is very much non communicable in kids. Spirometers is breath analyzer or device used for conducting spirometry test for the diagnosis of respiratory issues like COPD & Asthma. This project is redesign the spirometer for kids of 5-10 years old to encourage them and test their lung function for the betterment of their life.

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Methodology



Background

Introduction
Introduction to the scenario and describing the need for the product.

Justifying the topic
Reason for choosing the topic And defining how the product can benefit the users

Research

Secondary research
Collecting information from the internet regarding the problems caused and how people are affected

Primary research
Collecting information directly from the users to understand the situation and their problems better

Market study
Understand the existing products, their features, limitations , material used, manufacturing etc.

Contextual Inquiry
Understanding the product and user issues from a live case study

Design brief

Re-defining design brief
Defining the exact aim of the project

Finding out the possible design directions which will support the design brief, understanding the scope of the project and limitations

Ideations & conceptualization

Ideations and clustering
Ideations for different considerations that should be reflected in the product and clustering them for building concept

Concepts
Coming up with concepts that would fulfill the design brief

Final concept, detailing and validation

Concept evaluation
Coming up with the final concept, prototyping, and detailing it out

User validation

1.Introduction

1.1 What is spirometer?

A spirometer is a medical equipment used to perform spirometry tests for identifying lung illnesses such as COPD, asthma, bronchitis, and emphysema. A spirometer is frequently used to determine the cause of shortness of breath, examine the influence of pollutants on lung function, the effect of medication, and evaluate disease treatment progress.



Figure 1. Spirometer

1.2 Understanding spirometry test

Spirometry is a common office test used to assess how well your lungs work by measuring how much air you inhale, how much you exhale and how quickly you exhale.

Spirometry is used to diagnose asthma, chronic obstructive pulmonary disease (COPD) and other conditions that affect breathing. Spirometry may also be used periodically to monitor your lung condition and check whether a treatment for a chronic lung condition is helping you breathe better.

1.3 Who should take a Spirometry test?

- Chronic Obstructive Pulmonary Disease (COPD) patients
- Asthma
- smokers and former smokers
- Elders with respiratory issues
- persistent cough and sputum production
- frequent respiratory tract infections
- patients with undiagnosed respiratory symptoms

User group – 5-85

Frequency of use – Once in 3-6 months

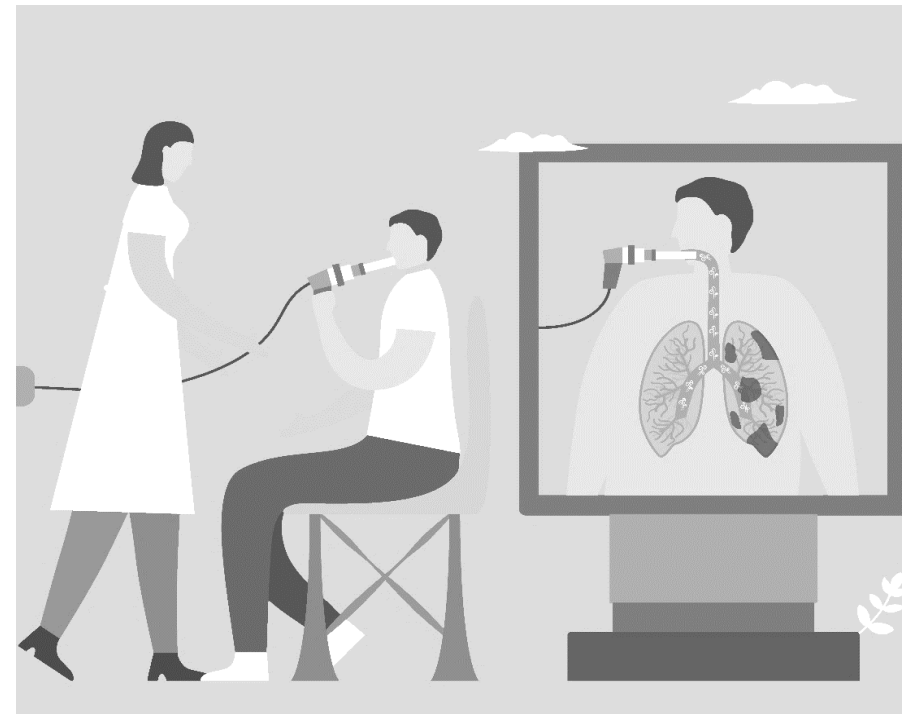


Figure 2. Clinical testing of spirometry

1.4 Indian Scenario

COPD (chronic obstructive pulmonary disease) is a prominent cause of sickness and death around the world. Developing countries are undergoing fast transformation. Socioeconomic development, industrialization, urbanization, changing age structures, and changing lifestyles have all contributed to an increase in the burden of non communicable diseases (NCDs) such as COPD in the countries. India has 18% of the world's population, but India accounts for 32% global respiratory diseases , Despite the huge and growing burden of COPD in India, more than 95% of COPD patients in the community remain undiagnosed. However, Several epidemiological studies have addressed the prevalence of COPD in India, with the methodology used and the definitions used for diagnosis being the limiting factors.



Figure 3. Indian scenario

2. Secondary study

2.1 Types of spirometers

2.1.1 Incentive spirometers

Incentive spirometers are handheld devices used to promote lung recovery after illness, infection, or surgery. This is a very basic device (pictured beside), which operates some indicative in it .It does not include any electrical components. Essentially, when the user breathes in or out, Balls inside on the inside of the tube will rise, actively measuring the amount of air taken in by the lungs Inhaled air is the only measurement an incentive spirometer can provide. The purpose in using an incentive spirometer is to promote lung activity and prevent fluid from building up, hindering pneumonia from developing.



Figure 4. Incentive Spirometers

2.1.2 Volumetric incentive spirometers

Volumetric Incentive spirometers are handheld devices used to promote lung recovery after illness, infection, or surgery. Apart from basic incentive spirometer this come with analog measurements on the device providing a volumetric guideline for adequate lung exercise. The measurements and indications Inspiratory indicator encourages patients to maintain an appropriate rate inspiration



Figure 5. Volumetric Spirometer

2.1.3 Peak flow meter

Unlike an incentive Spirometer, peak flow meters measure exhaled air from the lungs. These devices are also capable of measuring PEF (Peak Expiratory Flow Rate) and FEV1 (Forced Expiratory Volume in the first second you exhale). The digital aspect means they are electronically functioning devices that measure exhaled air via an **internal turbine system**. The problem with internal turbine systems is that they are susceptible to debris and damage, resulting in a shorter device lifespan. Though digital peak flow meters are useful most currently available on the market today, do not measure **FVC (forced vital capacity)** - the total amount of air measured during an FEV test. They are also non-rechargeable (require batteries) and are not compatible with any Bluetooth function or App features.



Figure 6. Peak flow meter

2.1.4 Desktop spirometers

Desktop spirometers are spirometers that are used extensively in clinics. This typically have a built-in display and printer and produce a report on thermal paper. They will often also send data to a PC for electronic reports to be archived, typically as a PDF.



Figure 7. Desktop spirometer

2.1.5 Medical workstation spirometers

Medical Workstations are stand-alone medical devices that can also be linked to your office network. A range of hardware can be connected to the device for different physiological measurements, including spirometers, BP, ECG, SpO2, medical scales etc. One medical workstation, the Vitalograph COMPACT, has a built-in spirometer.



Figure 8. Medical workstation spirometer

2.1.6 spirometers

Personal Spirometers allow those with chronic respiratory conditions such as asthma, COPD, chronic bronchitis, cystic fibrosis, and pneumonia to continually monitor and test their pulmonary function. Monitoring respiratory health on a daily basis can help those with chronic respiratory conditions identify anomalies, trends, and even improvements in lung function due to treatment.

2.2 Advantages of personal spirometers

Pocket-size Solution for Lung-sized Problem!

Conduct lung function tests at home with the world's first personal ultrasonic spirometer and track your lung health trends via mobile app.

Clinical Accuracy at Home

Perform pulmonary function tests with clinical precision, anytime, anywhere.

Hassle-free Mobile Application

Connect the Personal spirometer to your mobile phone via Bluetooth. An intuitive user interface guides you step-by-step through tests, alerts you about errors, and helps you improve your technique. Share your trend reports with your healthcare provider with the tap of a button.

Continuous Monitoring for Your Lung Health

Your doctor can track your test results and monitor your progress remotely as you perform your spirometry tests at home.



Figure 9. Digital spirometer

2.3 Understanding the Spirometry Results and What Happens Next

Spirometry will give the doctor information about why the patient may have a cough, shortness of breath, or noisy breathing and help diagnose certain lung problems. After the test, the patient can return to your normal daily activities.

Normal values are calculated based on age, height and gender. If a value is abnormal, a lung problem may be present. Sometimes a patient with normal lungs may have a breathing test value that is abnormal. The doctor will explain what the test results mean. Depending on the results of the test, the doctor may prescribe inhalers or medicines to help improve patient's lung function. The testing may be repeated at future visits to monitor the lung function.



Figure 10. Hand held Digital spirometer

2.4 Measurements in spirometer

What all measurements does spirometry test provide?

Peak flow readings are higher when patients are well, and lower when the airways are constricted. From changes in recorded values, patients and doctors may determine lung functionality, the severity of asthma symptoms, and treatment.

The standard spirometry test is a maximal forced exhalation (with greatest effort) after a maximal deep inspiration (completely full lungs). Several indices can be derived from this blow.

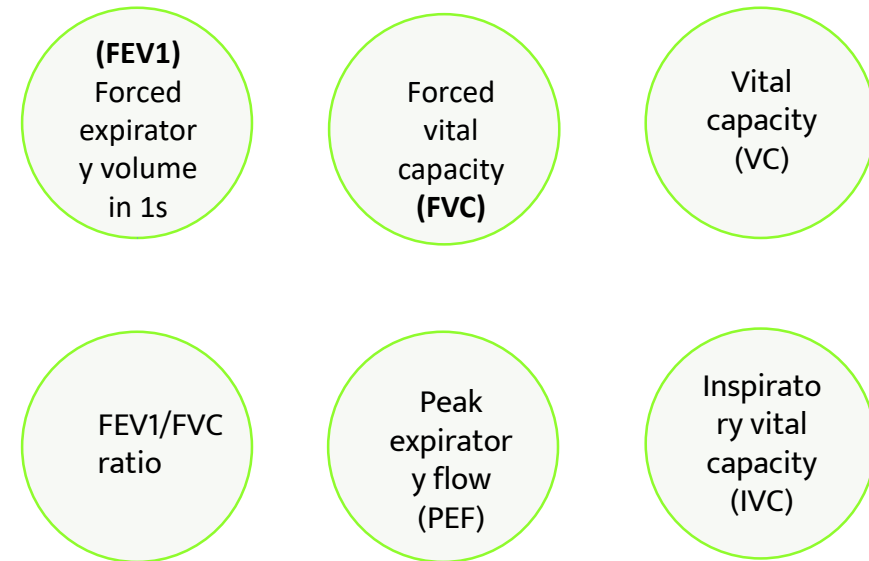


Figure 11. Measurable values in spirometer

- FEV1 – Forced Expiratory Volume in One Second – the maximum volume of air that the subject is able to exhale in the first second. This is the single most important index.
- FVC – Forced Vital Capacity – the total volume of air that the subject can forcibly exhale. This can take as long as 20s in subjects with obstructive lung disease.
- FEV6 – Forced Expiratory Volume in Six Seconds – the maximum volume of air that the subject is able to exhale in 6s.
- FEV6 is a useful and validated surrogate for FVC.
- FEV1/VC – the ratio of FEV1 to VC, FVC or FEV6 (whichever larger) expressed as a unit less ratio - not a percentage to avoid confusion with percent of predicted.

2.5 Factors effecting spirometry measurements

Age Lung function generally increases with age up to ~25 years, then declines with increasing age afterwards. Unfortunately, some lung function equipment will give patients aged <25 years larger predicted values than at age 25 years. To avoid majorly overestimating the predicted value for patients <25 years of age, the best course of action is input the subject's age as 16 years and then 25 years. If the predicted is larger at 16 years, then use the value for 25 years.

Sex Pre-pubescent males and females generally have the same lung function, but post-puberty, the growth of the thorax is greater in males, giving marked differences in lung volumes.

Height The taller the person, the bigger the lungs.

Weight Certain reference equations use weight to calculate reference values. Weight affects lung function in that increasing weight causes increasing lung function until obesity is reached, after which it has the opposite effect.

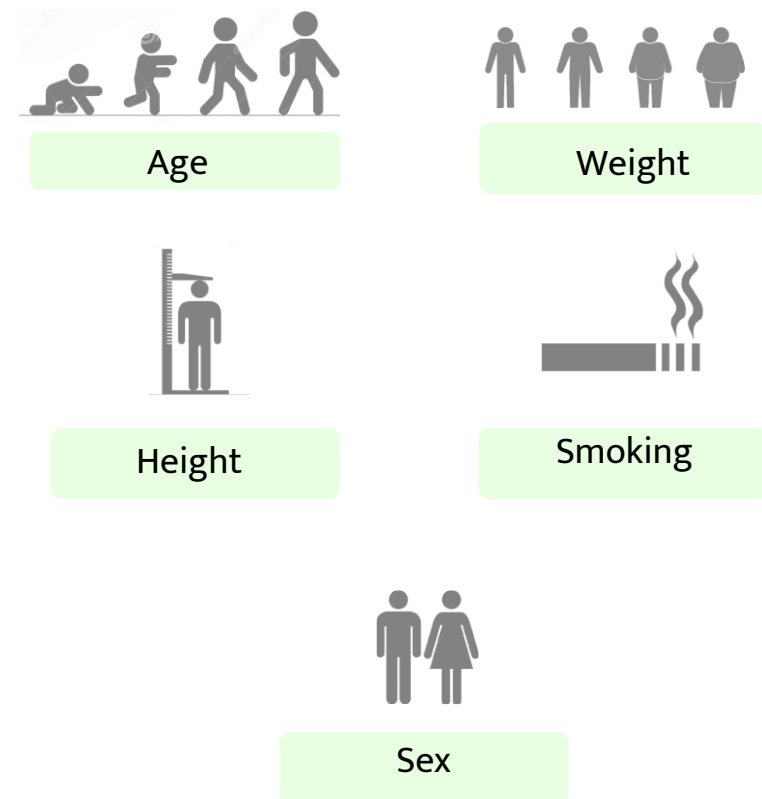
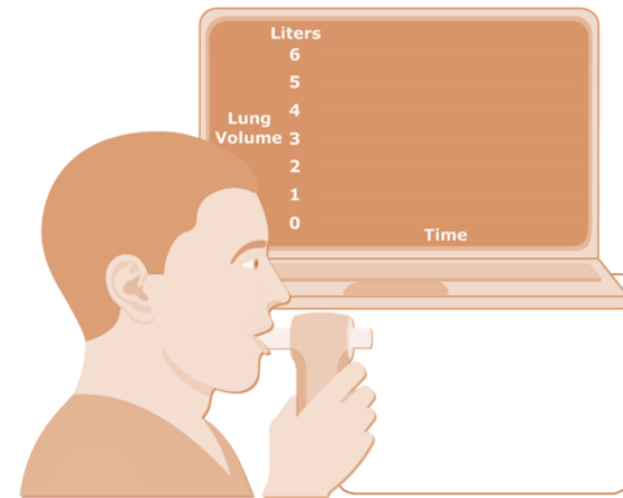


Figure 12. Factors effecting spirometry measurements

2.6 Spirometry test procedures

Test happens in 3 parts . 1st includes the pre- test instructions given to the patients in order to get the proper and accurate measurements of the lung condition of the patient without any bias. Next is pre-Bronchodilator test in which the test is done without any medicines after which a bronchodilator shot is taken and the test is repeated to know how much the lung capacity has increased after using the medicine shot.



Spirometry test procedure

Pre test instructions

Pre bronchodilator test

Post bronchodilator test

2.7 Pre test instructions

Below are some activities a that should be done certain hours before the test so that the test result of the patient does not get biased

Drinking alcohol	-----	4 h
Eating a large meal	-----	2 h
Vigorous exercise	-----	30min
Smoking	-----	24 hr

Figure 13. Spirometry test procedure

2.8 Clinic preparations

Understanding clinic preparations done in between each test

Hands must be washed between patients. Bacterial-viral filters should be used for all patients and thrown away by the patient at the end of testing. If an infectious patient requires testing, this should be performed at the end of the session and the equipment should be stripped down and sterilized/parts replaced (depending on what is being used) before being used again.

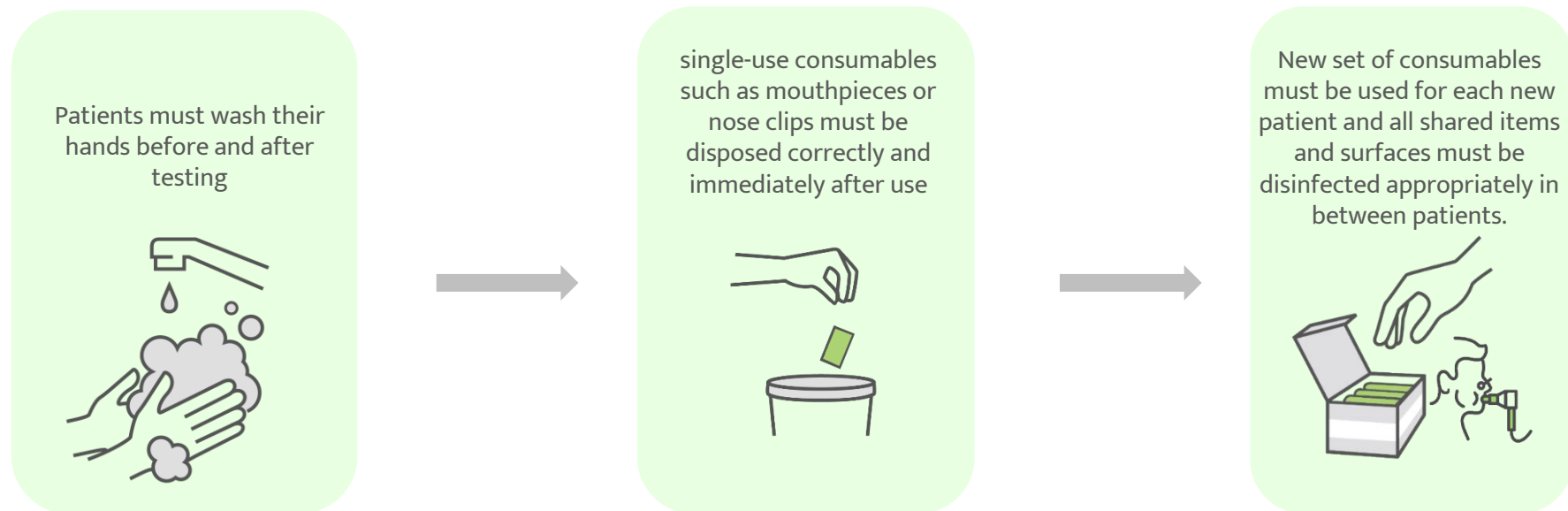


Figure 14. Clinic preparations

2.9 Patient positioning

Correct measurement posture is as follows.

- Sit upright: there should be no difference in the amount of air the patient can exhale from a sitting position compared to a standing position as long as they are sitting up straight and there are no restrictions.
- Feet flat on floor with legs uncrossed: no use of abdominal muscles for leg position.
- Loosen tight-fitting clothing: if clothing is too tight, this can give restrictive pictures on spirometry (give lower volumes than are true).
- Dentures normally left in: it is best to have some structure to the mouth area unless dentures are very loose.
- Use a chair with arms: when exhaling maximally, patients can become light-headed and possibly sway or faint.



Figure 15. what to expect during the test

2.10 Techniques for measuring

There are a number of different techniques for performing spirometry.

Before performing the forced expiration, tidal (normal) breaths can be taken first, then a deep breath taken in while still using the mouthpiece, followed by a further quick, full inspiration.

Alternatively, a deep breath can be taken in then the mouth placed tightly around the mouthpiece before a full expiration is performed.

The patient can be asked to completely empty their lungs then take in a quick full inspiration, followed by a full expiration.

Encouragement makes a big difference, so don't be afraid to raise your voice to encourage the patient, particularly near the end of the maneuver. The patient needs to keep blowing until no more air comes out and the volume-time trace reaches a plateau with <50 mL being exhaled in 2 s [1]. Some patients, particularly those with obstructive disease, may find it difficult to exhale completely on a forced maneuver. A relaxed VC may produce better results in this case.

FVC and FEV1

deep breath in, as large as possible
blows out as hard and as fast as possible
keeps going until there is no air left.

VC

Patient takes a deep breath in, as large as possible
blows steadily for as long as possible until there is no air left.

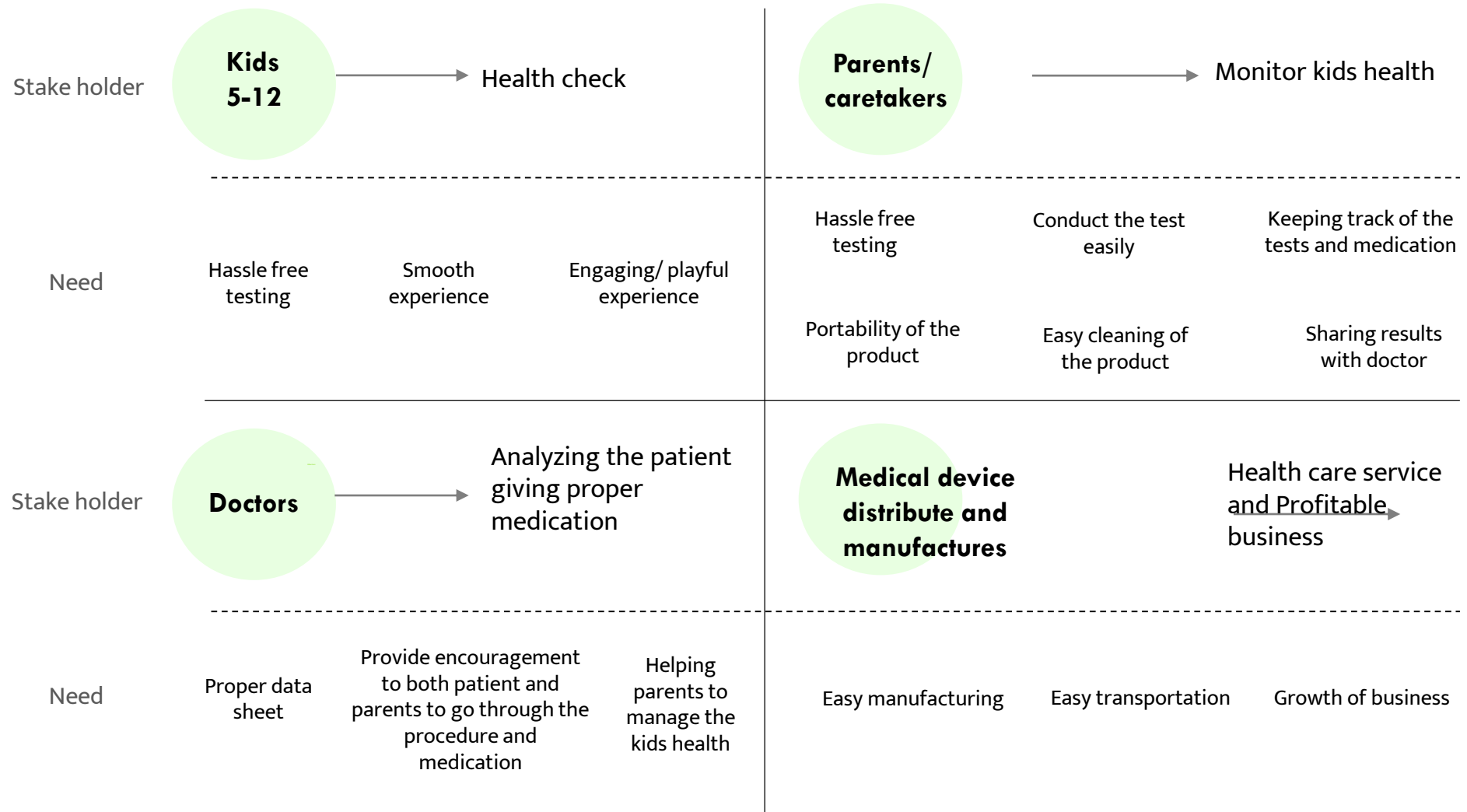
Peak flow rate

Obtained from the FEV1 and FVC maneuvers

IVC

The IVC maneuver is performed at the end of FVC/VC by taking a deep, fast breath back in after breathing all the way out.

2.11 Stake holders



2.12 Market study

There are many spirometers on the market. They can be divided roughly into a group that primarily measures volume and a group that primarily measures flow. Quality control and calibration should be performed on a regular basis to ensure that a device (still) functions appropriately. The types have different characteristics and are optimal for different circumstances (from a simple peak-flow meter to an ultrasonic device to measure a patient in a pulmonary function lab).

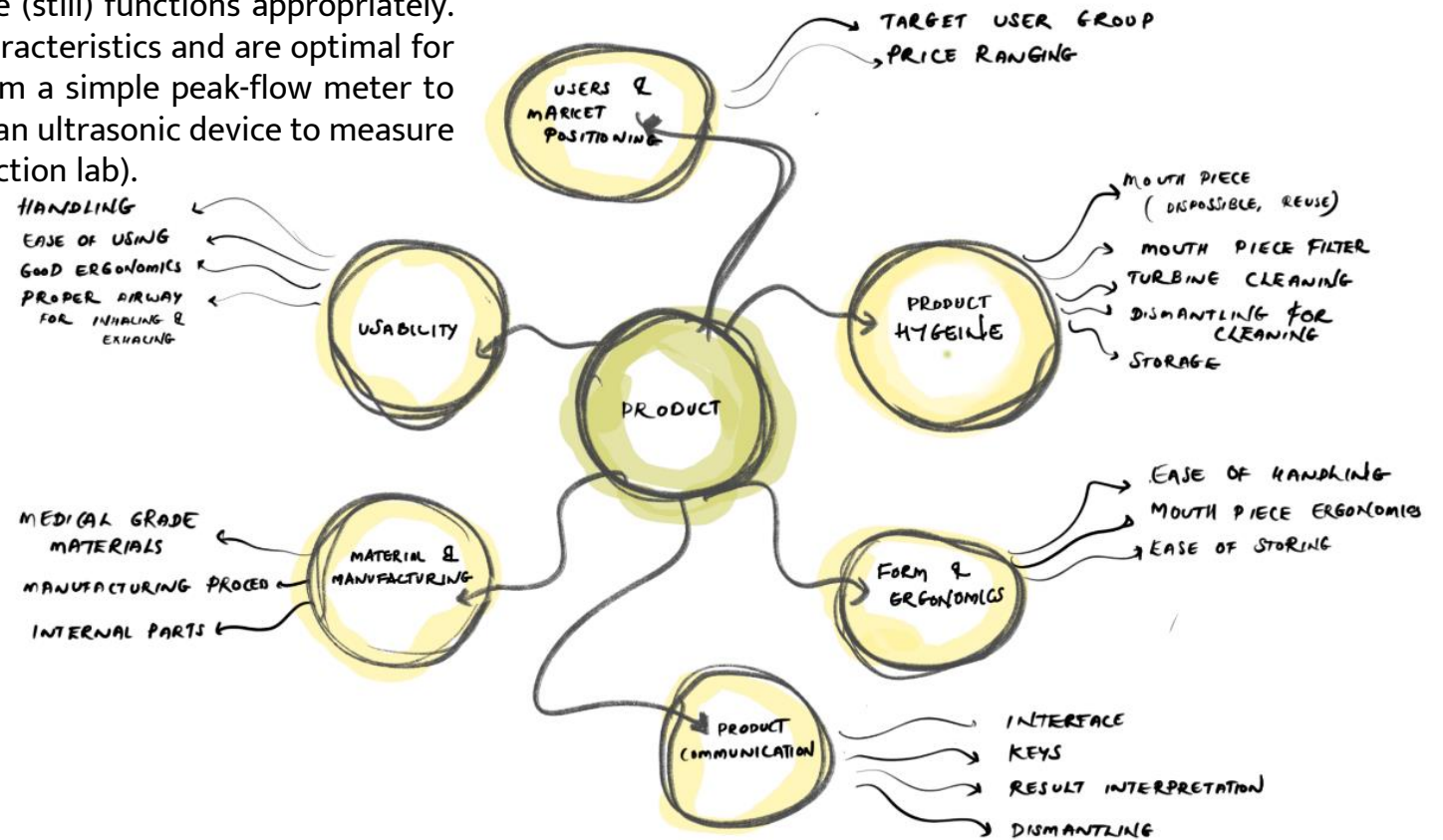


Figure 16. structure for Market study

2.13 Market study- Selling products

				
<p>CareFusion Micro I Spirometer Price – 33,000/-</p>	<p>Contech handheld spirometer Price – 25,000/-</p>	<p>Contech spirometer sp10 Price – 21,000/-</p>	<p>Spirobank Smart spirometer Price – 14,000/-</p>	<p>Carefusion pulmolife spirometer Price – 8000/-</p>
<ul style="list-style-type: none"> • Choice of four indices can be displayed • Confirming diagnostic interpretation • Post bronchodilator comparison • PC software for unit configuration 	<ul style="list-style-type: none"> • Data memory, delete data • Trend chart display • Rechargeable • Battery power display 	<ul style="list-style-type: none"> • Data memory, delete data • Trend chart display • Rechargeable • Battery power display • Display lung condition by light • Ultra thin design, easy portable 	<ul style="list-style-type: none"> • Clinical grade Spirometry & Oximetry parameters • Suitable for ages 5 – 93 years • Real time Oximetry test • Can save and share the report anytime. 	<ul style="list-style-type: none"> • Simple and fast operation • Clear LCD display • Can identify patients who may require a full spirometry test • low-cost

2.14 Insights

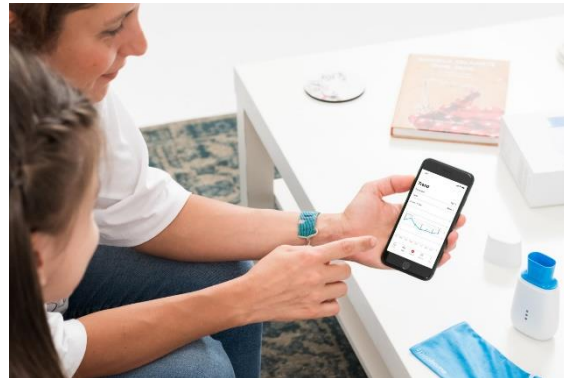
- Expensive to middle range pricing of the product
- Only few provide reusable mouth piece with the product
- Width of the mouth piece not suitable to all ages
- Filters of most of the product are not removable for cleaning, Only MIR provide that . The one with fixed does not posses a better cleaning ergonomic also
- Poor communication on the interface
- Poor storage facility
- Unappealing form

Figure 17. Selling products

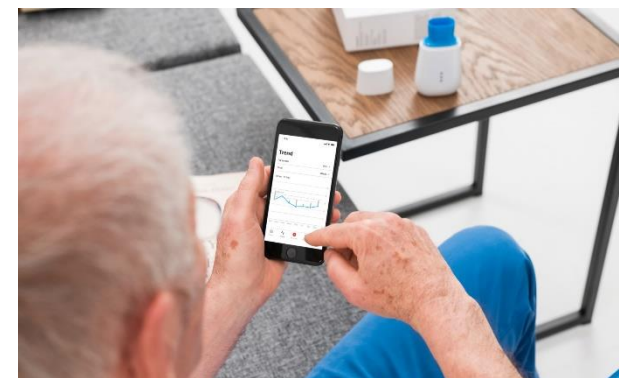
2.15 Features in modern spirometers



Results sharing,
virtual spirometry



Trend data



In-App guidance



Clinical accuracy at home



Portable



Cloud integration

Figure 18. Features in modern spirometer

2.16 Components of personnel spirometer



Figure 18. Components in a spirometer

3 .Primary research

3.1 Contextual inquiry

Dr. Miti Shah Chest clinic, Pulmonologist

Conducted user study at Dr.Miti Shah chest clinic at Sion West , Mumbai. Understood the whole set up , how the test is performed , what all are the equipment's used for testing and the precautions and measurements took for hygiene.

Test space:

The test was conducted in an air conditioned room where there was a table and chair mainly for the instructor and the patient and an extra chair for the bystander. The room also include a bed and that was provided for if at all the patient feels dizzy or unconscious while testing which may occur

Equipment used:

The products used for the test were MIR Spirometer which is a PC spirometers , PC spirometer make your desktop or laptop PC into a spirometer when you run the software application provided with the device. This also is the most widely used spirometry system used in small respiratory clinics. They also had a set of disposable mouth piece of 2.8 inch , laptop which is connected with the spirometer and a weighing machine



- Instructor
- Spirometry test pc and setup
- Patient
- Caretaker

Figure 19. Testing setup



Products used

MIR Spiro spirometer

Disposable Mouth piece

Laptop

Figure 20. Products used

User-1 - Age 32

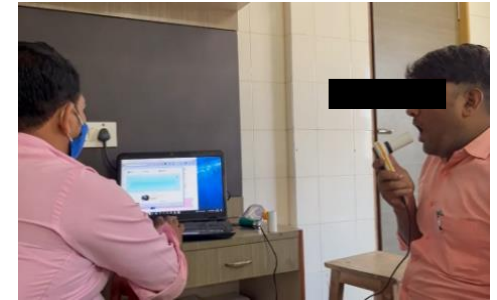
Ravi is of 32 years old from Mumbai. He had mild lung infection and asthma and that was the reason of the test. Ravi used to conduct the test once in 4 months . Ravi also use to smoke and was reluctant to reveal that to the instructor

1. Was told to check weight
2. Came and sat at the chair
3. Asked about patient history and smoking history.
4. Took the Spirometer
5. Technician described about the procedure
6. Conducting the test
7. Taking bronchodilator shot
8. Repeating the testing
9. Leaving.

Procedure:



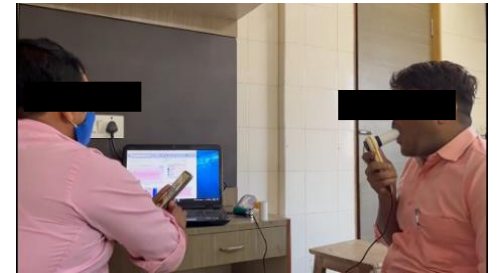
Checking weight,
Sitting upright



Placing the mouth piece



Inhaling In



Breathing out



Repeating test after 10min

Figure 21. Testing user 1

User 2 - Age 9

Ajmal is of 9 years old from Mumbai. He had asthma issues for 2 years and that was the reason of the test. Ajmal used to conduct the test once in 3 months .

1. Was told to check weight
2. Came and sat at the chair
3. Asked about patient history
4. Took the Spirometer
5. Technician demonstrated and clearly described about the procedure
6. Conducting trial test.
7. Conducting the test
8. Taking bronchodilator shot
9. Repeating the testing
10. Leaving

User-2 - Age 9yrs



Testing room



Placing the mouth piece



Inhaling In



Breathing out

Figure 22 Testing user 2

3.2 User interviews

3.2.1 Questionnaire for caretaker

What is the reason of testing?
How frequently do you take your child for testing?
What is the mode of travel to clinic for testing?
How far is it from your place?
How does the kid react to the visit to clinic and test?
How do you find your kids acceptancy for going for the test?
How easy do you find your kid to go and do spirometry test?
Does the kid perform spirometry test easily and what are the issues he use?
What is role at clinic by standing as a care taker while performing the test?
Can you brief the instructions given to the kid before and while testing?
How do you find the hygiene of the spirometer at clinic?
Are you familiar with personnel spirometer?

3.2.2 Questionnaire for technician

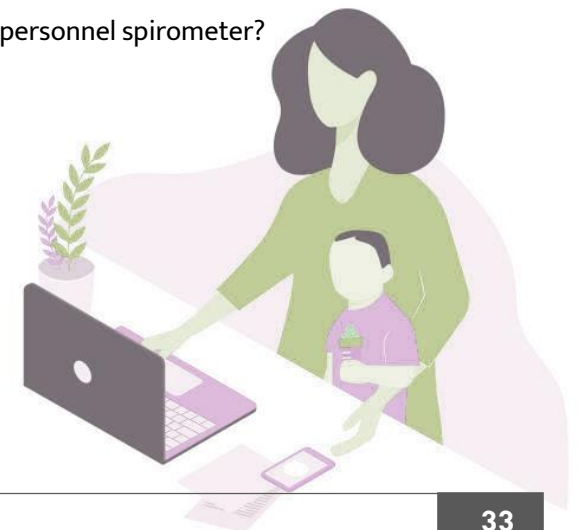
At what stage of lung capacity illness do you recommend a patient to use a personnel spirometer?
What are instructions you give to the patients which they should follow while performing spirometry test?
Instructions for using the product
How do you interpreting the result
How frequent do the patients visit the clinic to test their lung capacity?
How difficult do you find the patient to perform the test?
What are the issued followed by poor hygiene of the product?
Do patients opt visiting clinic or monitoring from home what do you think and what is best for COPD and asthma patients?
How often do your patients who use a personal spirometer share their results with you?
If yes how does they share the data?
How do your patients react to the outcome of the tests they perform?

3.2.3 Parents Interview

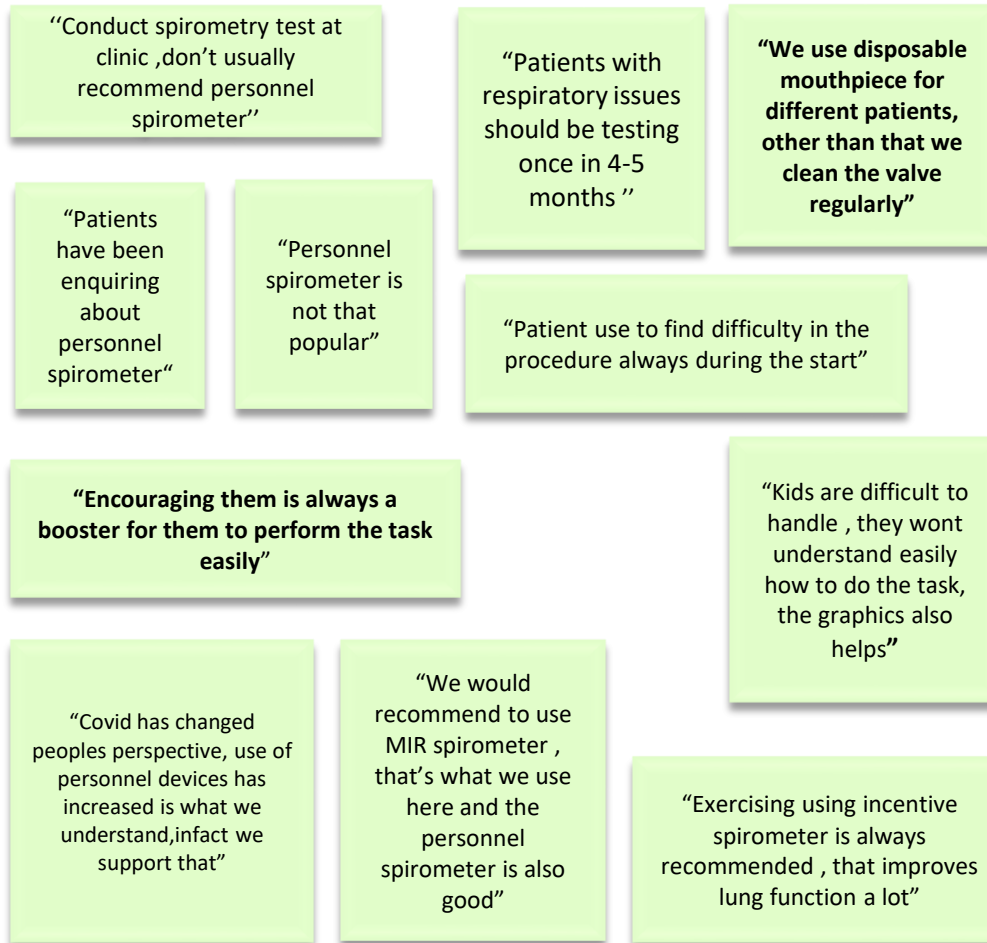
Primary research



- What is the reason of testing?
- How frequently do you take your child for testing?
- What is the mode of travel to clinic for testing?
- How far is it from your place?
- How does the kid react to the visit to clinic and test?
- How do you find your kids acceptancy for going for the test?
- How easy do you find your kid to go and do spirometry test?
- Does the kid perform spirometry test easily and what are the issues he use?
- What is role at clinic by standing as a care taker while performing the test?
- Can you brief the instructions given to the kid before and while testing?
- How do you find the hygiene of the spirometer at clinic?
- Are you familiar with personnel spirometer?



3.2.4 Expert Interview



How do you conduct the test in clinic
 How do you find the patients understanding the procedure?
 How often should the patient do the spirometry test?
 What are the hygiene preparations done in the clinic?
 Which personnel spirometer do you suggest to the patients?
 What all problems do the patient encounter during the test?
 At what stage of lung capacity illness do you recommend a patient to use a personnel spirometer?
 Do you have an idea of how frequent they use it to track their lung capacity?
 What are instructions you give to the patients which they should follow while using a personnel spirometer?
 Instructions for using the product?
 Instructions for interpreting the result?
 if not using personnel spirometer how frequent do the patients visit the clinic to test their lung capacity?
 What are the issues followed by poor hygiene of the product?
 Do patients opt visiting clinic or monitoring from home what do you think and what is best for COPD and asthma patients?
 How often do your patients who use a personal spirometer share their results with you?
 If yes how does they share the data?
 How do your patients react to the outcome of the tests they perform?



3.3 User journey

3.3.1 Before use

	Technician					Patient				
Steps	Replacing the mouth piece	Checking & recording weight of the patient	Enquiring about alcohol & smoking consumption/ exposure to smoke etc	Asking patient to take normal breath and stay calm	Introducing the procedure	Waiting for the patients turn	Checking weight	Getting comfortable with the seat	Taking normal breath , being comfortable	Understanding the technique
What they do	Technician is replacing it without any gloves, direct contact with his hand	Showing the weighing machine and asking patient to stand on that	Recording the details about consumption in the software	making the patient feel calm and good	Calmly outlining the steps to the patients	Waiting outside the test room	Moving to weighing machine and checking weight	getting comfortable with the chair		Listening to the technician
		Recording weight in the software					Saying it loud for the technician to record	Looking the space around, people around		Knowing the product
What they say	'we replace a new disposable mouth piece for each patients'		'Some people refuse to say or feel uncomfortable to say'		'Most of them get it done with few trials, and kids find difficulty to understand'	Travelling to the clinic is a hassle + its good that it is situated to a reachable place	Saying it loud for the technician to record	Space has never bothered us but people do	Boy don't usually listen to that, usually use to be in their own world	It feels its easy to do but its not
What they feel	Frustrated		exhausted	monotonous	exhausted	Frustrated	Bored uncertainty	Bored uncertainty	Bored Awkward	Focused Concentrated
Pain points	taking new mouth piece and placing it each time for different users		reluctant to reveal			Time consuming	moving from one place to another			impatience of the technician effects the patient

3.3.2 During use

	Technician						Patient					
Steps	Giving spirometer to patient	Encouraging the patient to do the test	Preparing the bronchodilator shot	Helping the patient to take the bronchodilator shot	Resuming the test	Simultaneously checking the test result, if not proper doing it again	Holding on the spirometer	Placing the mouth piece inside the mouth	Taking big deep breath through the mouthpiece	Exhaling out through the mouth piece as fast as possible/ blowing out slowly	Taking in bronchodilator shot	Repeating the test
What they do	Taking the product and handing it to patient	Calmly encouraging, repeating what he has to	Taking the medicine, spacer and keeping it ready	Taking the medicine, spacer and keeping it ready	Re-introducing the procedure	Re-assuring that the test is				blowing out Fast till the lung is fully empty	Removing the spirometer and placing spacer mouth piece	blowing out Fast till the lung is fully empty
		Conducting multiple trials, encouraging all the time	In between encouraging the patient to do the test properly	In between encouraging the patient to do the test properly	Encouraging the patient to inhale and exhale	Re checking whether the results are recorded correctly, asking patient to leave				blowing out slowly till the lung is fully empty	Inhaling in the medicine	blowing out slowly till the lung is fully empty
What they say	The product is good to hold and easy	We are keeping on repeating the same, some time voice gets low		always need to help patients to use inhaler through spacer because they are not used to it	This time patient use to do better but they get tired or sweaty most of the time	Some times it use to go to 9-10 rounds when the patient couldn't understand how to do or when they get exhausted in between	'The product is small easy to hold'	Feel like mouth piece is oversized and is difficult to keep it in mouth for a longer time	Its easy to breath in through the wide mouth piece but feels weird because of the size	difficult to breath out slow, feels lungs are already empty	Re-introducing the procedure	difficult to breath out slow, feels lungs are already empty, cough coming in between due to bronchodilator
What they feel	Focused and anxious	Exhausted		Exhausted	Satisfied Concerned	Assuring	Satisfied Concerned	embarrassed worries	Anxious	Anxiety	short of breath	exhausted
Pain points		effort put in for every patients	Multi-tasking	Since patients are not acquainted with spacers, need to explain procedure for that also		Multi tasking	Changing holding positions due to Poor ergonomics	Bigger size of the mouth piece	Finding difficulty in the first go all the time while testing			Poor confidence

- The patient tends to change the holding position frequently because of the poor ergonomics of the product .
- Disposable mouth piece is an extra effort to remove and replace
- It is difficult to make them understand the procedure and perform the task
- Kids had an extra interface to encourage them to breathe as instructed for good results.
- Mouth piece size was bigger for kids
- Hygiene issue of turbine because it's not cleaned and dust remains on the mouth pipe and turbine which is not good for asthma and COPD patients
- The position of the turbine is also very close, chances of getting dust is close.

3.3.3 After use

	Technician		Patient	
Steps	Removing and disposing the used mouth piece	Recording the test result	Placing the spirometer back on table/ or giving to the technician	Taking restful and normal breath
What they do	after user 1- Placed the mouth piece on the table instead of disposing it right after the use	Checking whether the data's are correctly recorded	Kept the spirometer on the table	Resting back and taking normal breathing
What they say	difficult to breath out slow, feels lungs are already empty, cough coming in between due to bronchodilator	difficult to breath out slow, feels lungs are already empty, cough coming in between due to bronchodilator	difficult to breath out slow, feels lungs are already empty, cough coming in between due to bronchodilator	difficult to breath out slow, feels lungs are already empty, cough coming in between due to bronchodilator
What they feel	Multi-tasking	Focused	Relax and calm	Relax and calm
Pain points	Hygiene issue			

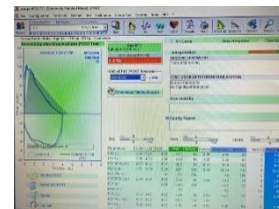
3.4 Observations and user points

- The patient tends to change the holding position frequently because of the poor ergonomics of the product.
- Disposable mouth piece is an extra effort to remove and replace
- It is difficult to make them understand the procedure and perform the task
- Kids had an extra interface to encourage them to breathe as instructed for good results.
- Mouth piece size was bigger for kids
- Hygiene issue of turbine because it's not cleaned and dust remains on the mouth pipe and turbine which is not good for asthma and COPD patients
- The position of the turbine is also very close, chances of getting dust is close.



Holding of the product

Disposing mouth piece



Test interface for adults



Test interface for Kids – Graphics for encouragement



Changing holding position positions due to poor grip



Uncleaned turbine used throughout the day for all patients

Figure 23 Pain points

4. Design brief

Redesigning digital spirometers for children (5–10 years old) with bronchitis, asthma, and other respiratory conditions

The availability of better spirometry equipment with incentives and modified criteria will enhance the for acceptability and repeatability of the test with the young kids.

Target Users

Children (5–12 years old) with bronchitis, asthma, and other respiratory conditions

- Easy maintenance and cleaning of the product
- Enhancing the handling of the product in terms of usability, grip and comfort
- Portability and better storing of the product
- Enhancing the connection of the product with the users Incorporation of two contradicting activities in a single product and making it attractive and same time engaging for the kids
- User friendly



Figure 24 Kid using spirometer

4.1 Design Direction

Incorporating testing and exercise into one product can help children’s feel more connected to it, which will increase how often they use it.

Children find incentive spirometers, a respiratory disease exercise tool, to be a challenge and a fun. Given this, improving the incentive spirometer's aesthetics and combining it into digital spirometry equipment can increase the product's use by kids without any reluctance.

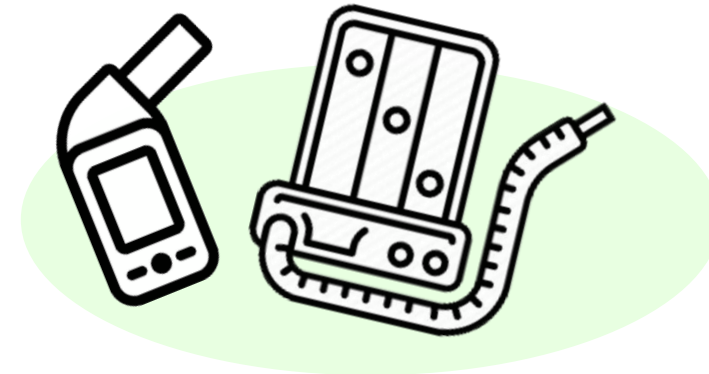


Figure 25 two types of spirometer in one device

Promoting co-ordination

enhancing user coordination to simultaneously perform periodic tests and exercise for lung improvement

Increasing grip & comfort

improving the grip's comfort to improve the grasp and ergonomics of the device

Enhancing management

enhancing management by making the product easy to carry and store

Improving quality of life

Increasing the level of device cleanliness thus raising both life's and the product's quality

5. Defining Users

Around 30-35% of children worldwide suffer from allergy disorders, with the prevalence of these conditions increasing in recent years. Childhood allergic disorders include atopic dermatitis, allergic rhinitis, asthma, and food allergies, with asthma being the most frequent chronic ailment among children and adults. Asthma causes the tiny airways in the lungs to narrow due to inflammation, resulting in wheezing, coughing, trouble breathing, and chest tightness. It is frequently underdiagnosed and undertreated, particularly in low- and middle-income countries, and has a negative influence on quality of life.

Improvement in spirometry readings following bronchodilator is more sensitive in children and is vital to help confirm a diagnosis of asthma. Epidemiological data is based mainly on questionnaire-reported symptoms, which may not always be accurate, resulting in variations in the prevalence rates of asthma. Although confirming reversible airflow restriction is just as critical in children as in adults when diagnosing asthma, the practical application of spirometry in children is even more difficult. These concerns were highlighted by statistics from the United States, which showed that while 52% of physicians who offered primary care to children used spirometry, only 21% used it according to national recommendations and only 35% of those surveyed were confident in interpreting the test results. Another study reported that 21% of spirometry values were misinterpreted, highlighting the importance of training and quality control before using spirometry on children in primary care.



Figure 26 . Kid using spirometer

Survey

Conducted a survey on how people use incentive spirometer for enhancing their lung performance. No of samples took- 14

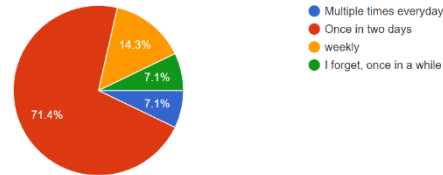
The samples included 11 year old kid and elders as well.

Reason of using the device included patients with Asthma, severe breathing issues, lung infection and to improve lung performance after surgery.

Insights

- Frequency of use is average of thrice in a week.
- Patients use incentive spirometer more often and barely clean the device after using
- Commonly used incentive spirometer is the one without measurements
- For spirometry testing patients are referred to visit clinics or hospital

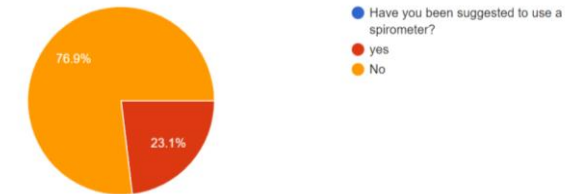
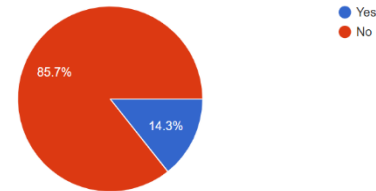
How often do you use your incentive spirometer?
14 responses



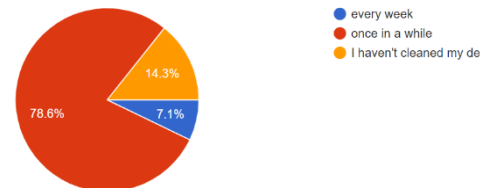
What do you do to measure your lung capacity if needed?
13 responses



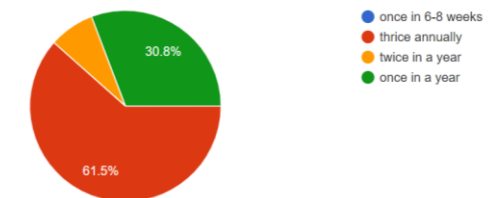
Does it have measurements on it or is it purely for exercise?
14 responses



How often do you clean the device?
14 responses



How frequent do use you measure?
13 responses



5.1 Understanding the Users

Kids
5-12 Years

What attracts them?
What engage them ?
What motivates them ?

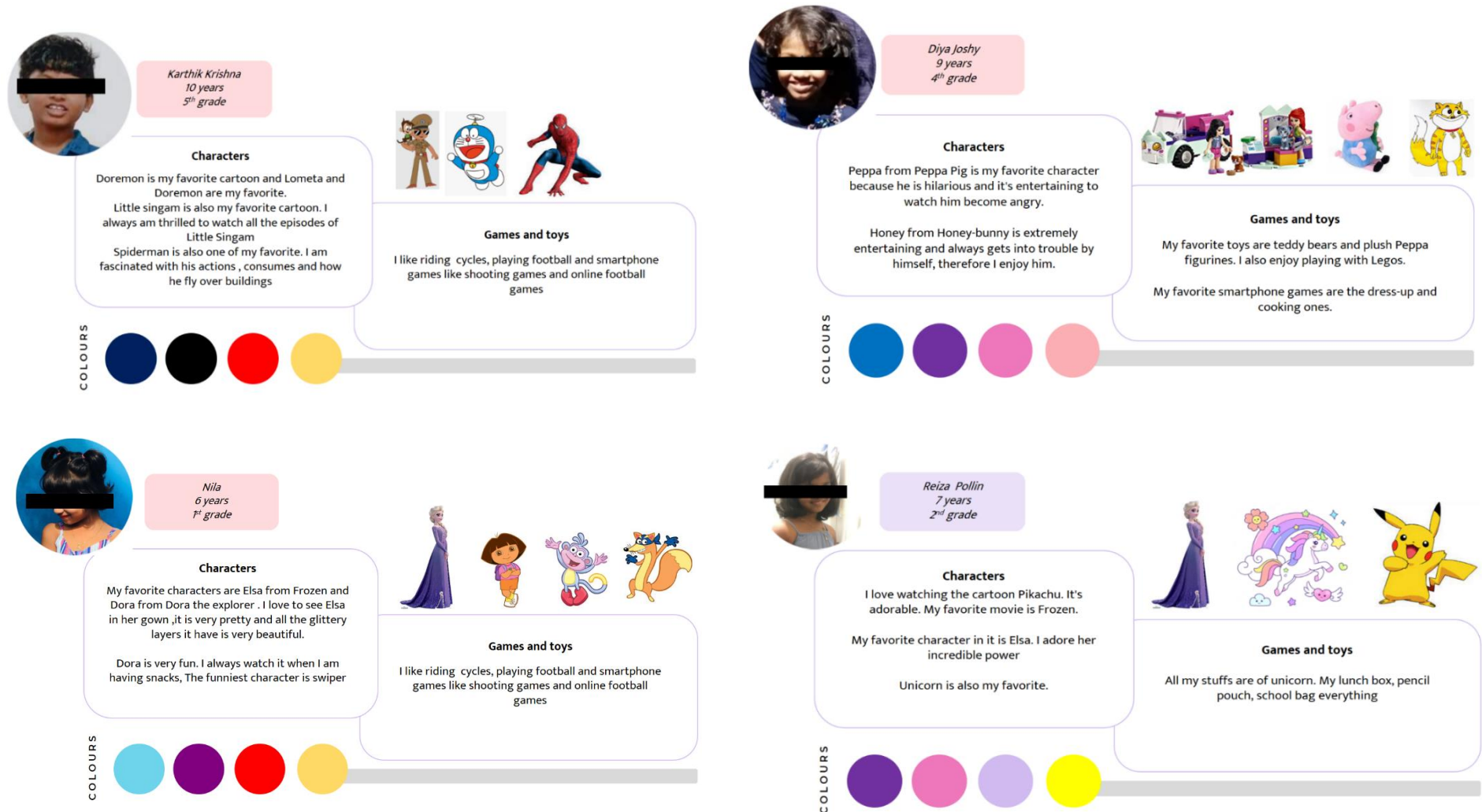


Figure 27 Children's interest

5.2. Understanding the Users- Interest and favorite toys

ATTRACTIVE

Attractive forms for fidgets

Squishing materials from Orag and Queer: Slimes / Slimes with textures.

Change of toys through the kids: Colorful to soft & subtle colours.



STATIONARIES

Animal form bags



CHARACTERS



Figure 27 Children's interest

5.3. Mood Board

Because the target audience is 5-10 year olds who enjoy toys and bright colors, I chose some images for my mood board that are basic, colorful, and have animal characteristics.



Figure 28 Mood board

6. Ergonomic consideration

Measurement	Study population						
	Children		Adults		Dif- ference	P- value	Size (chil- dren/ adults, %)
Mean	SD	Mean	SD				
Shoulder breadth (cm)	31.0	2.2	42.5	2.3	11.5	<0.0001	73
Arm length (cm)	50.8	4.7	71.3	4.5	20.5	<0.0001	71
Hand length (cm)	13.6	1.0	18.8	1.1	5.2	<0.0001	72
Hand width (cm)	7.5	0.6	10.0	0.9	2.5	<0.0001	75
Index finger length (cm)	4.8	0.1	7.2	0.5	2.4	<0.0001	67
Index finger width (mm)	14.6	1.1	20.3	2.4	5.7	<0.0001	72
Index finer mass (g)	10.1	1.9	28.0	7.8	17.9	<0.0001	36

Figure 29. Anthropocentric data about children s hand

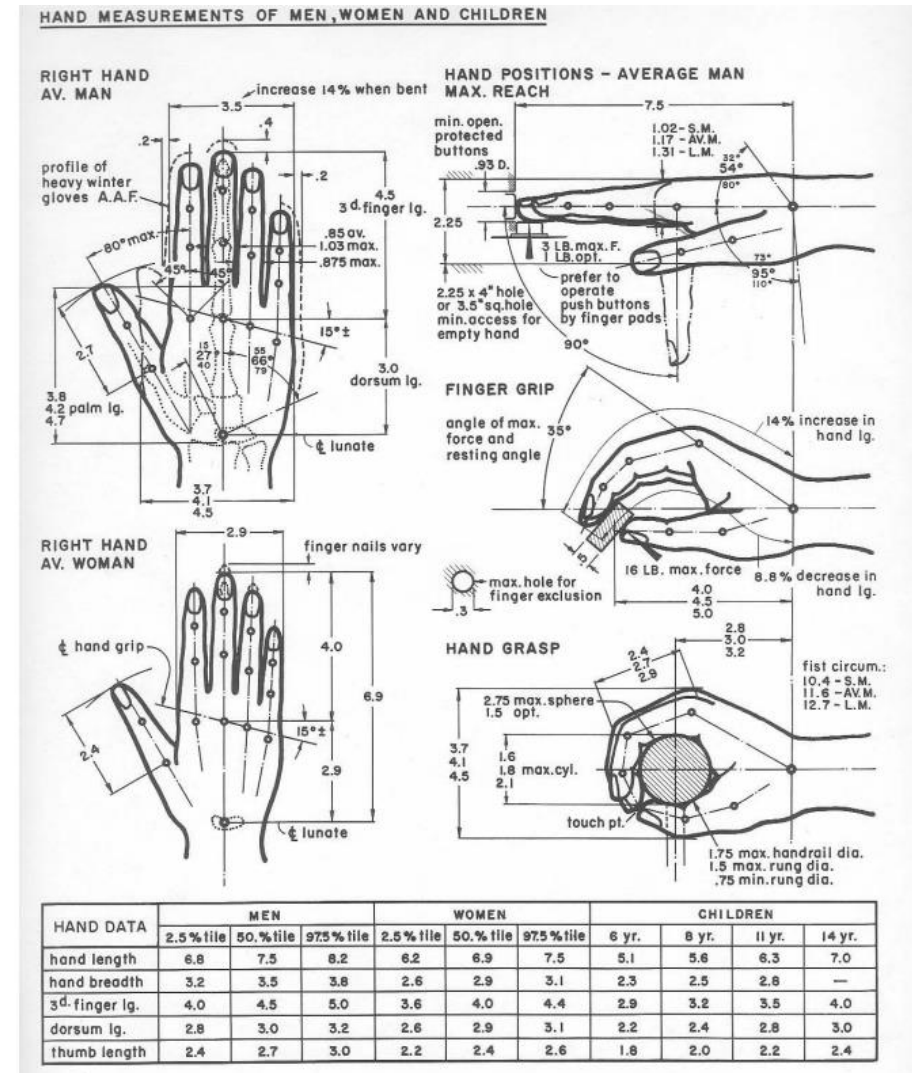
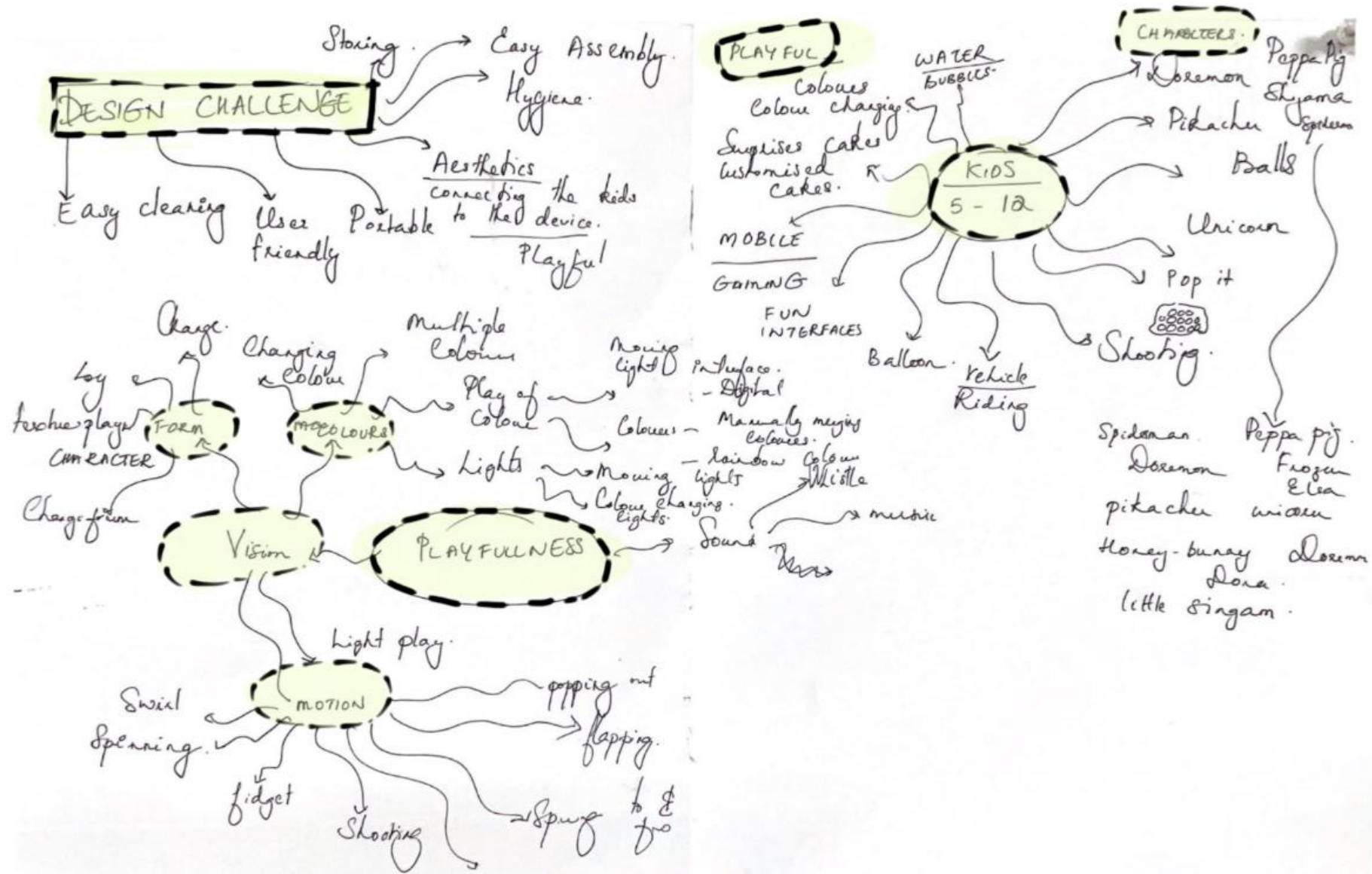
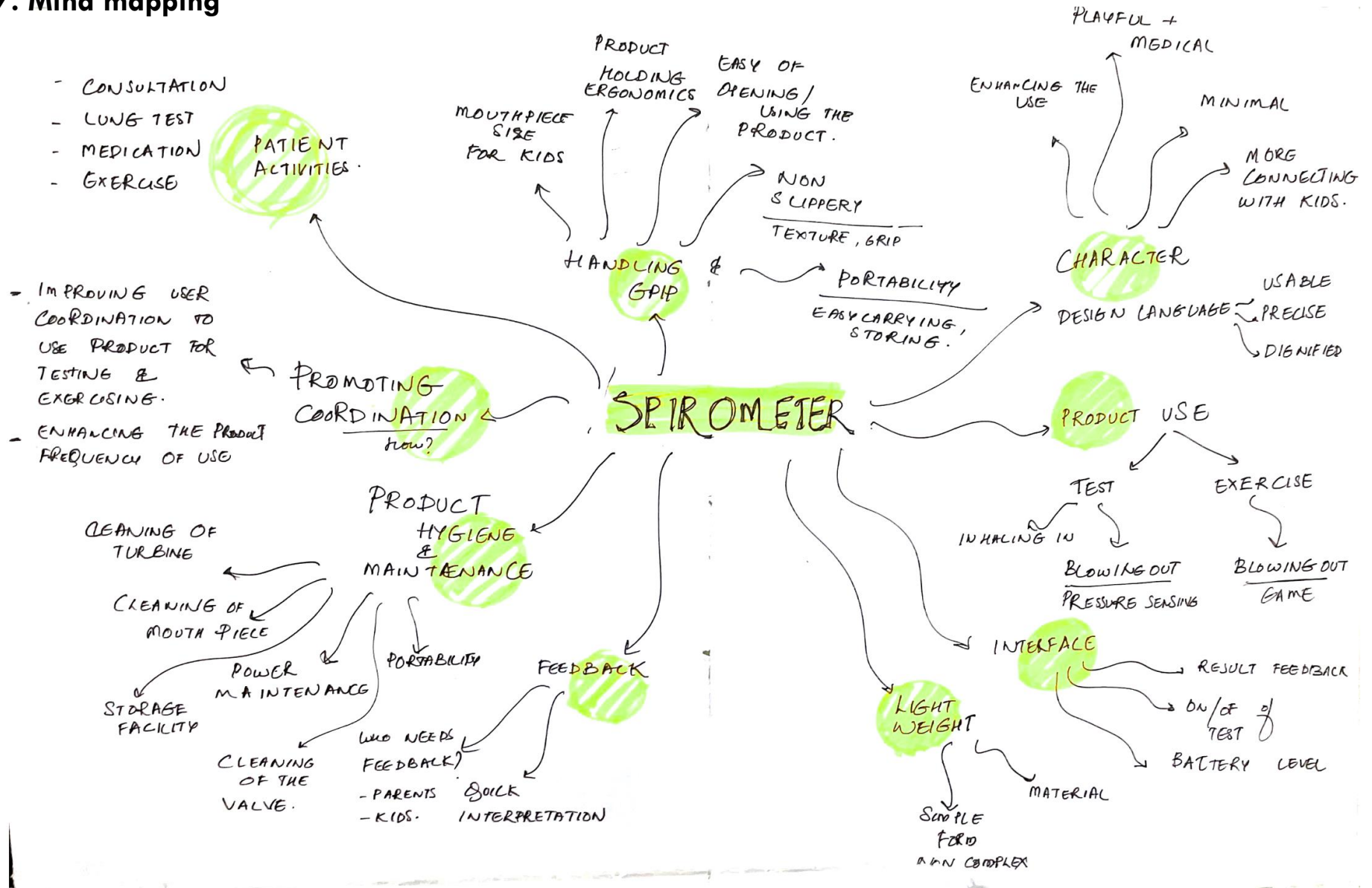


Figure 30. Hand Measurement.

Mind mapping



7. Mind mapping



8. ideations

8.1. Ideations for hygiene

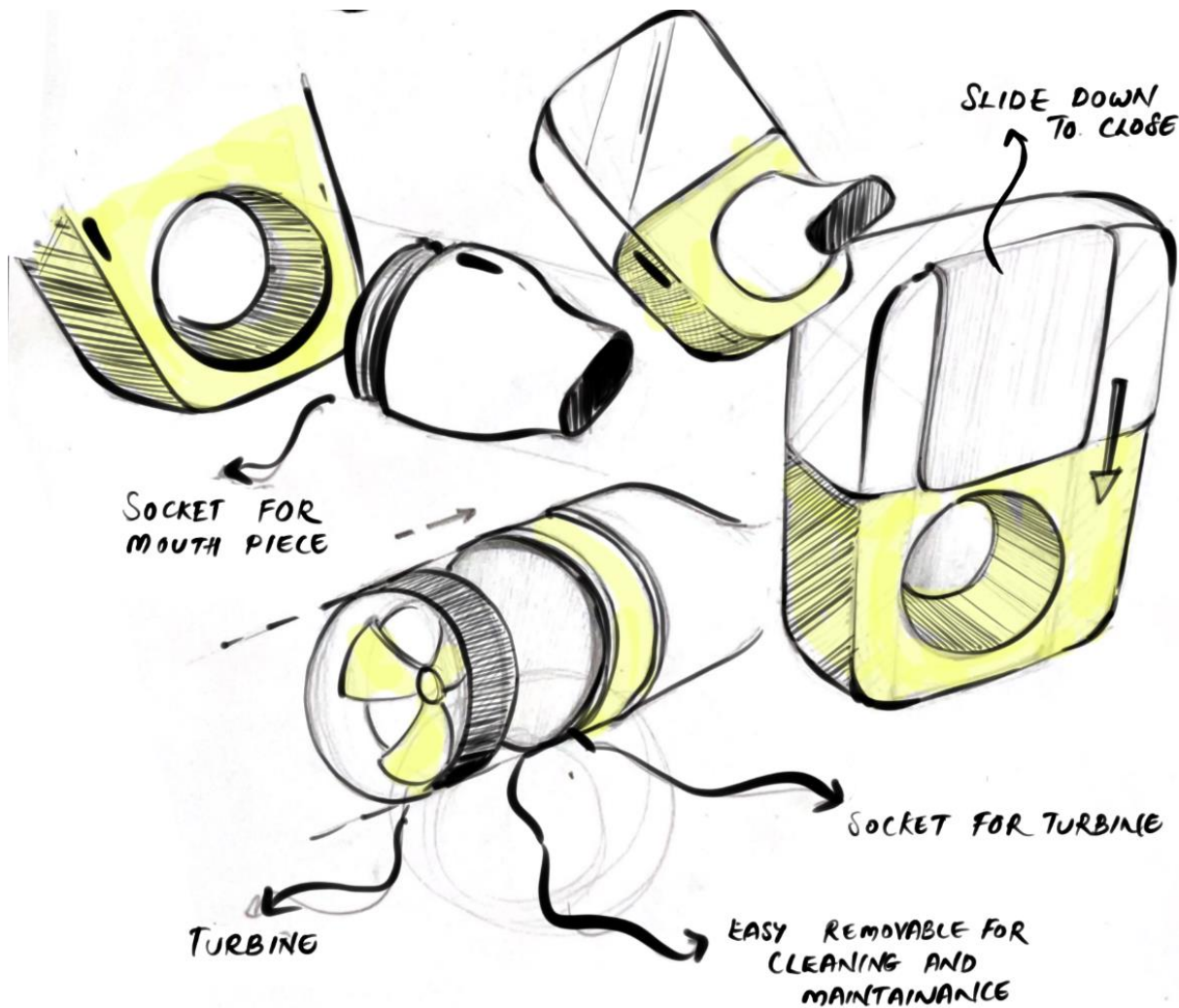


Figure 31 Ideation for hygiene

Ideation for better hygiene

Making the product dis assemble and assemble easily so that it can be removed for cleaning it thoroughly

8.2 Ideations for portability

Design

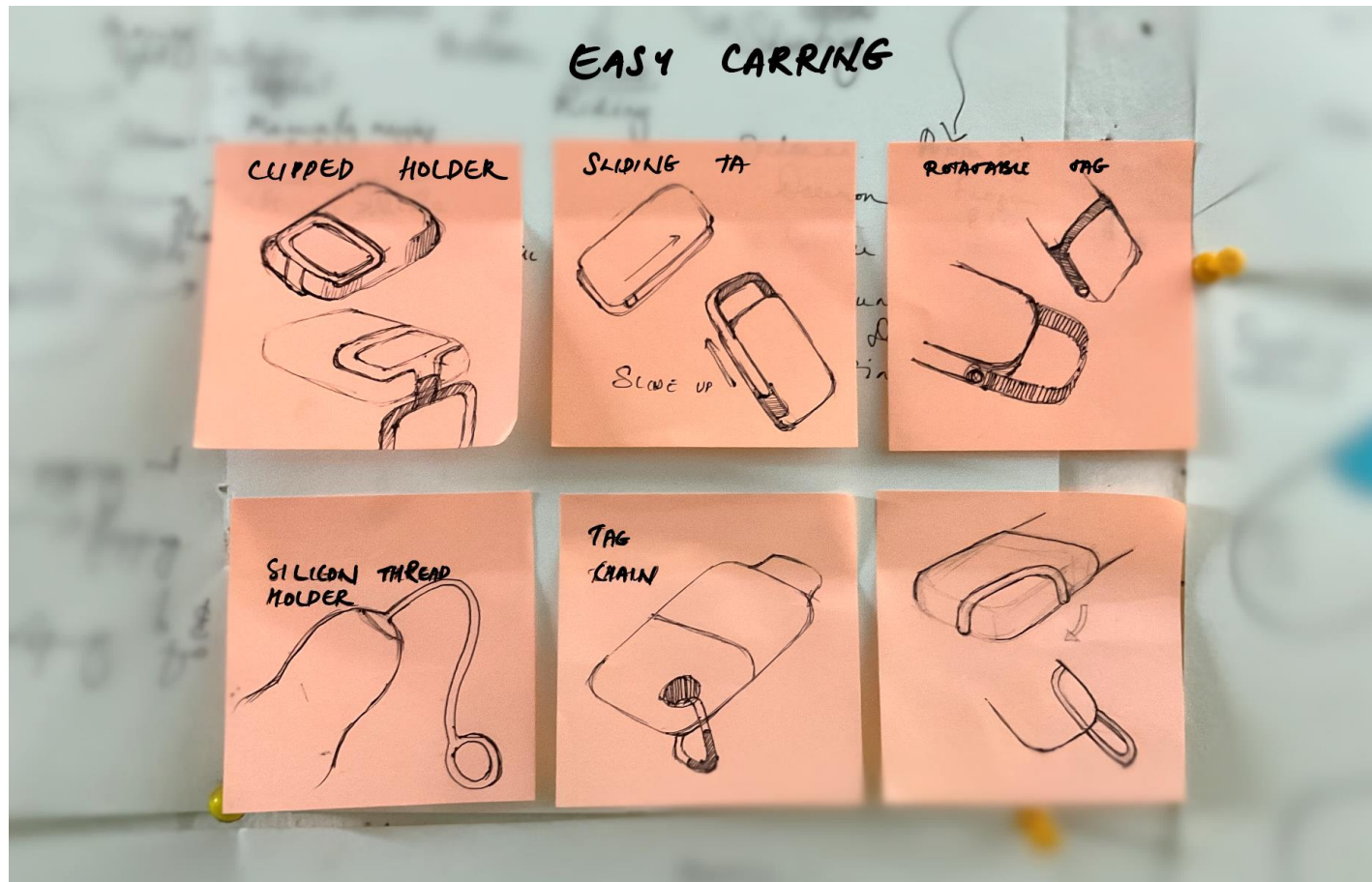
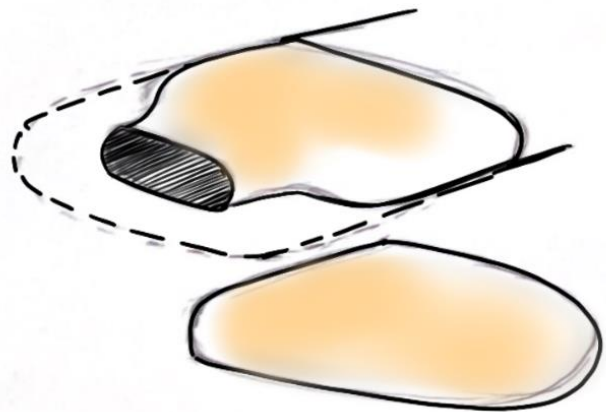


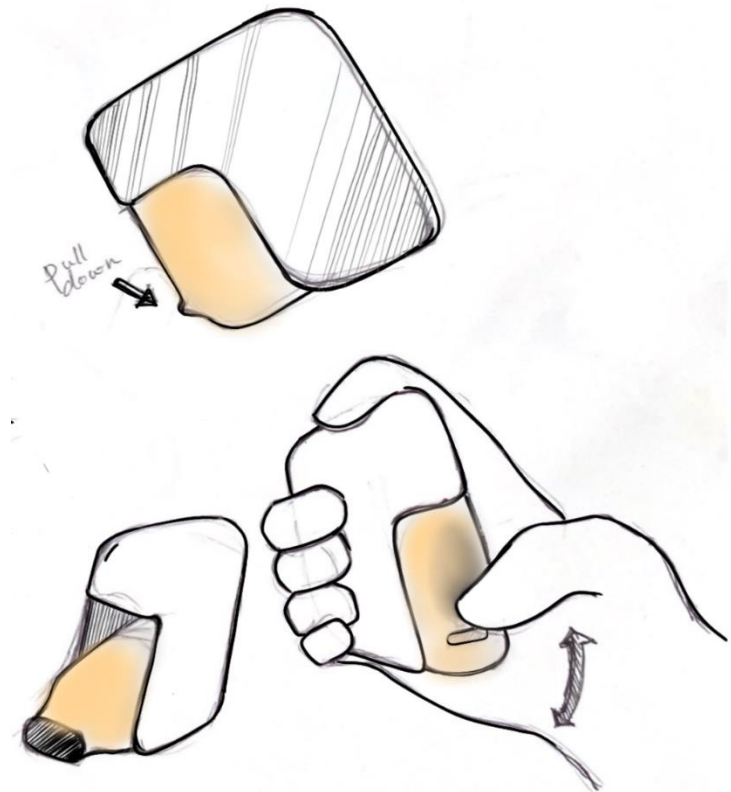
Figure 32 Ideation for Portability

8.3 Ideations for portability



Simple cap for the mouth piece

Providing simple cap to cover up the mouth piece from dirt



Flip down and use

Pulling down the mouth piece for use. Other push it back so that it is safe from dust

Figure 33 Ideation for Portability

Ideations for portability

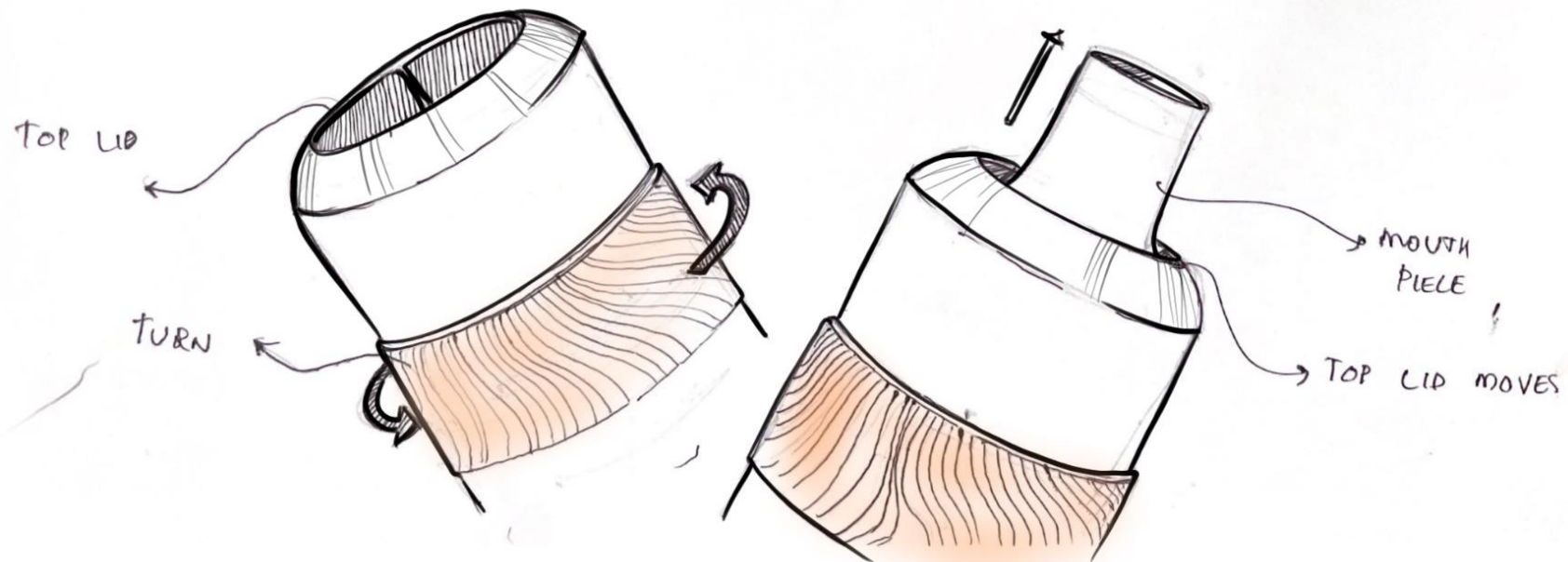


Figure 34 Ideation for Portability

Rotate and use

Mechanism similar to lipstick mechanism where while rotating the bottom top lid opens and mouth piece pop out for use

Ideations for portability

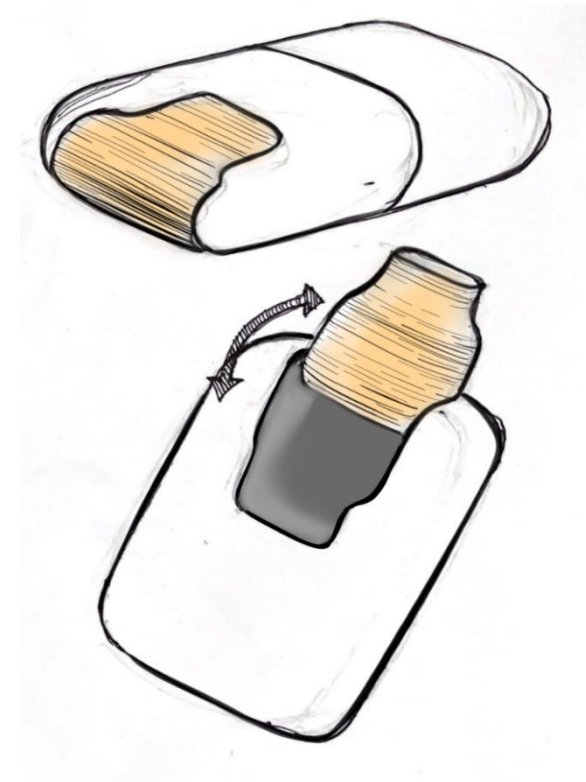
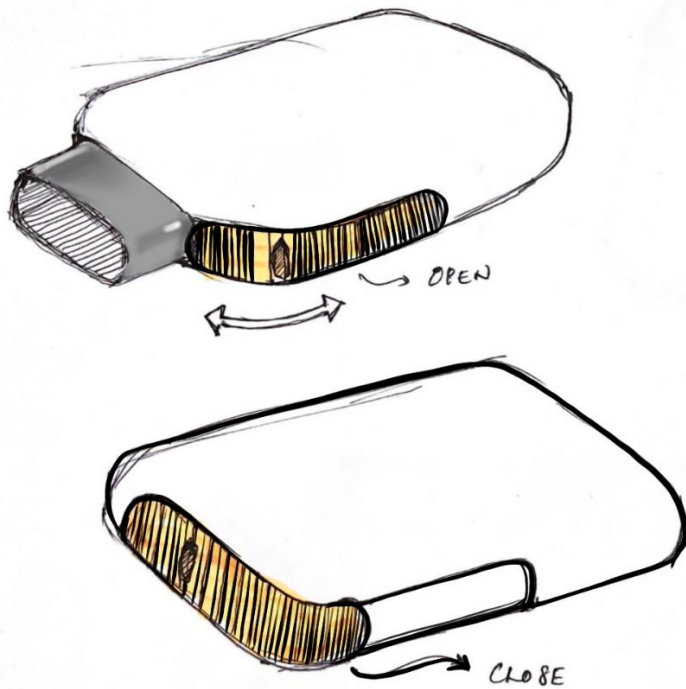


Figure 35 Ideation for Portability

Slide and use

Lid with tambour mechanism, when sliding down mouth piece projects out for use. Slide the lid back to make the device compact

Flip and use

Flipping the mouth piece up for use, flipping down make the device compact

Ideations for portability

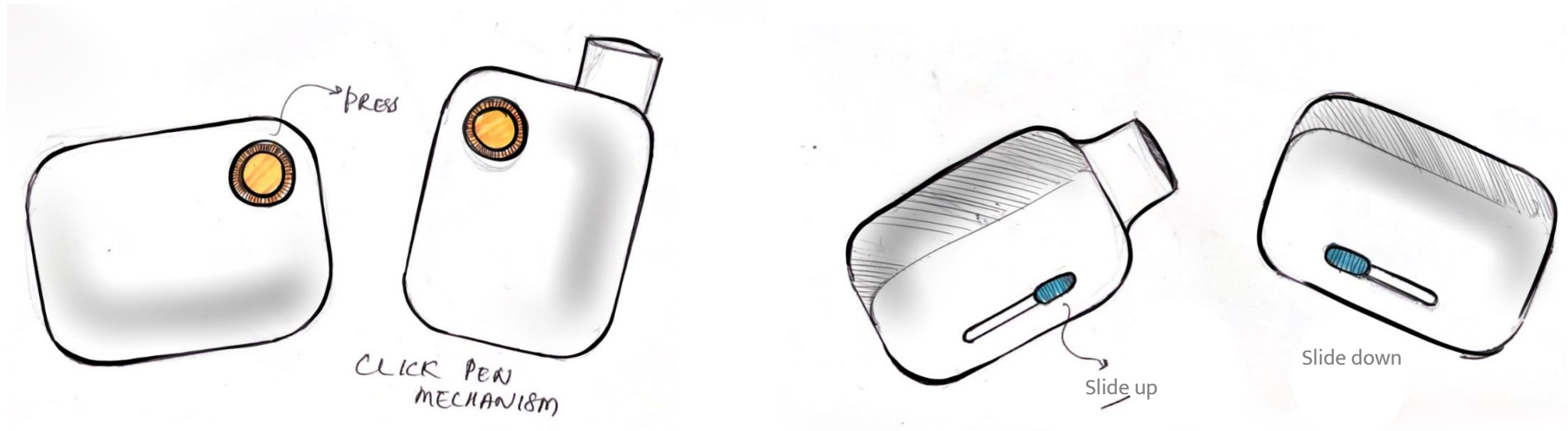


Figure 36 Ideation for Portability

Click and use

Smililar to click pen, the mouth piece pops out when clicked for use, push it back with hand to make it compact

Slide in & out

Similar to slide pen this use the mechanism of slide in and out for retracting the mouthpiece from the inner chamber of the device

Ideations for portability

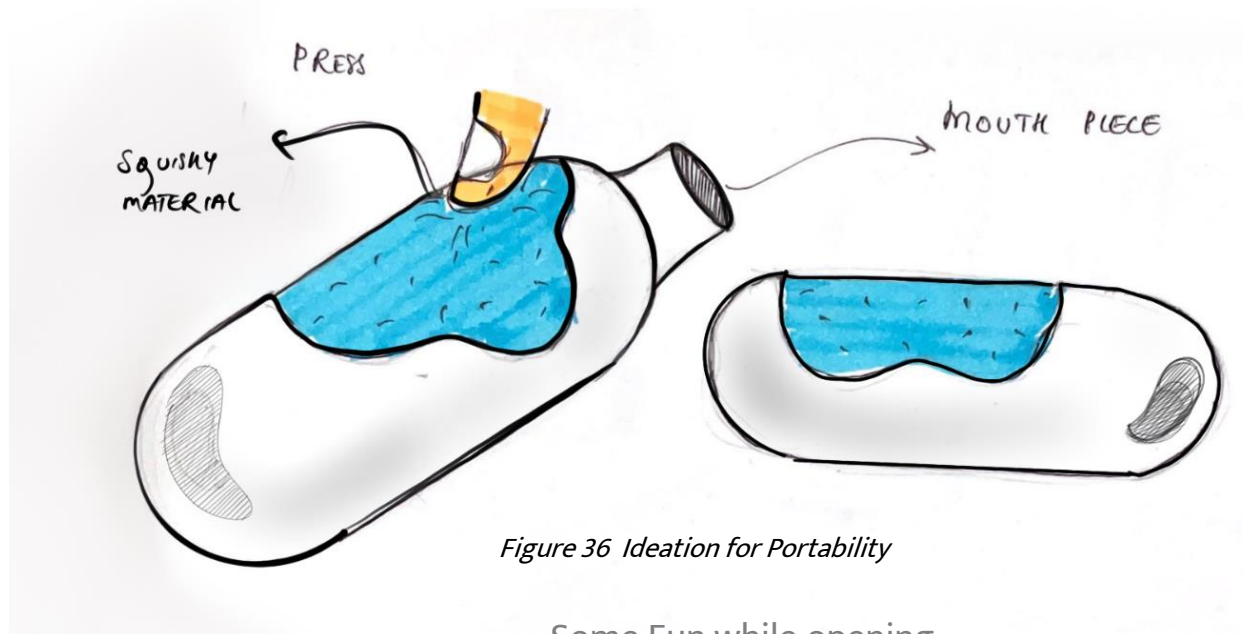


Figure 36 Ideation for Portability

Some Fun while opening

Children are constantly fascinated by slimes and other squishy, transformable materials, this mechanism is made of a layer of squishy substance that may be utilized to click and retract the mouthpiece from inside.

Ideations for portability

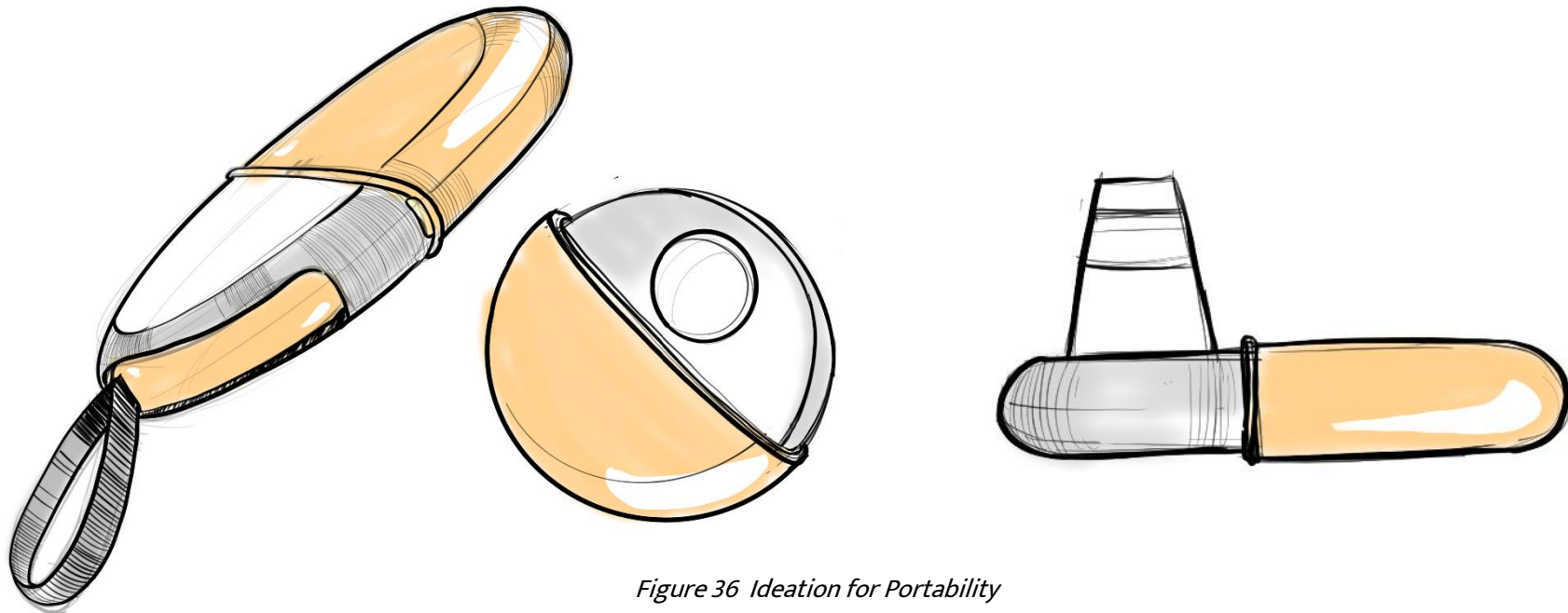


Figure 36 Ideation for Portability

Twist to open

Turn the lid down to release the mouthpiece for usage. While operating the device, the Lid also conceals the tag. Carry the device easily using the tag.

8.4 Ideations for Playfulness

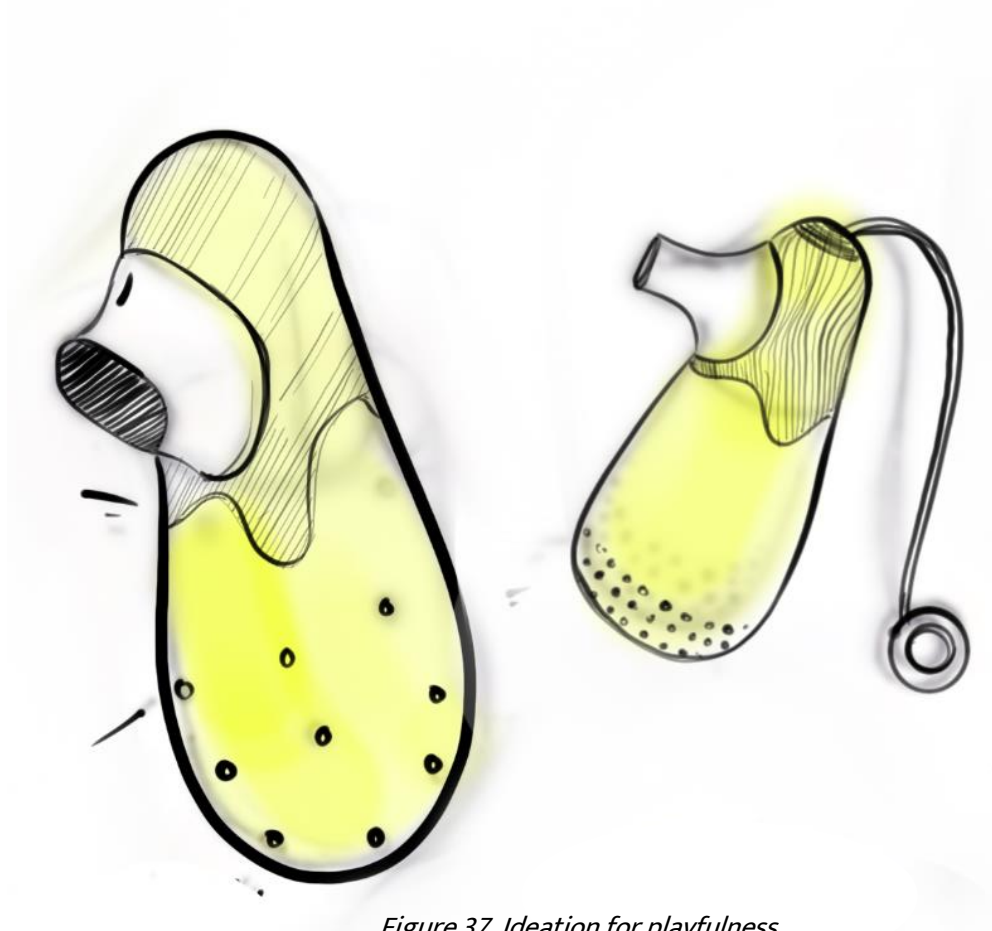


Figure 37 Ideation for playfulness

Blow for music

While blowing out, the shape makes a whistling sound.
Play with the sound and for a variety of sounds, blow firmly.

Ideations for Playfulness

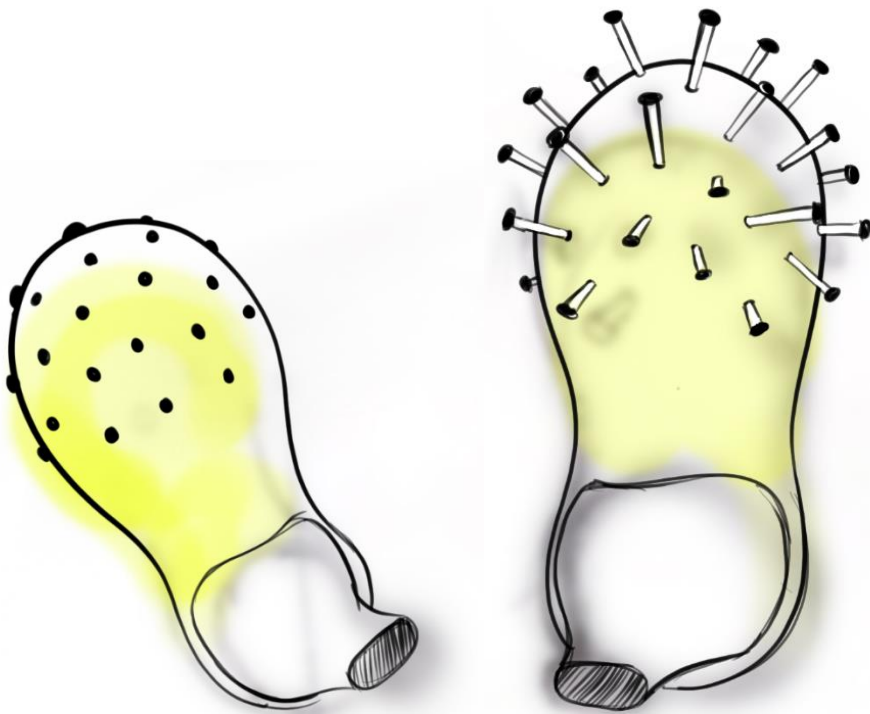


Figure 38 Ideation for playfulness

Projecting beads

When blown out, the beads on top of the form extend, creating attractive shape and sound

Ideations for Playfulness

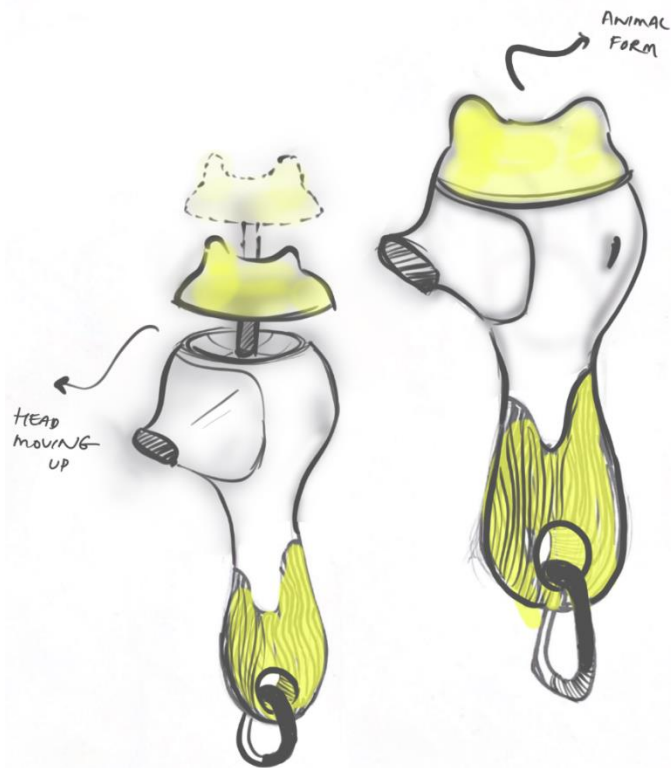


Figure 39 Ideation for playfulness

Projecting head

This one is given an animal form in which when blown the head moves up. The final target height can only be reached when blown forcefully

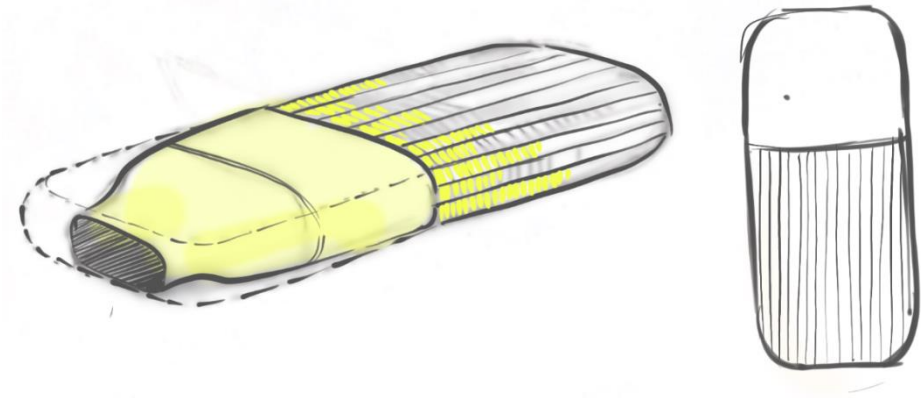


Figure 40 Ideation for playfulness

Lights play

When blown out, the light spreads out, more forcefully then it spreads till the tip which will be the target for the user

Ideations for Playfulness

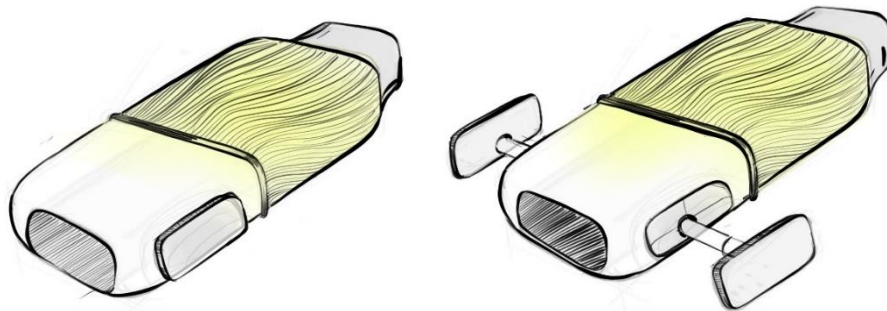


Figure 41 Ideation for playfulness

Minimal form in which there is two projection that can move to and fro according to the blow strength to both the sideways

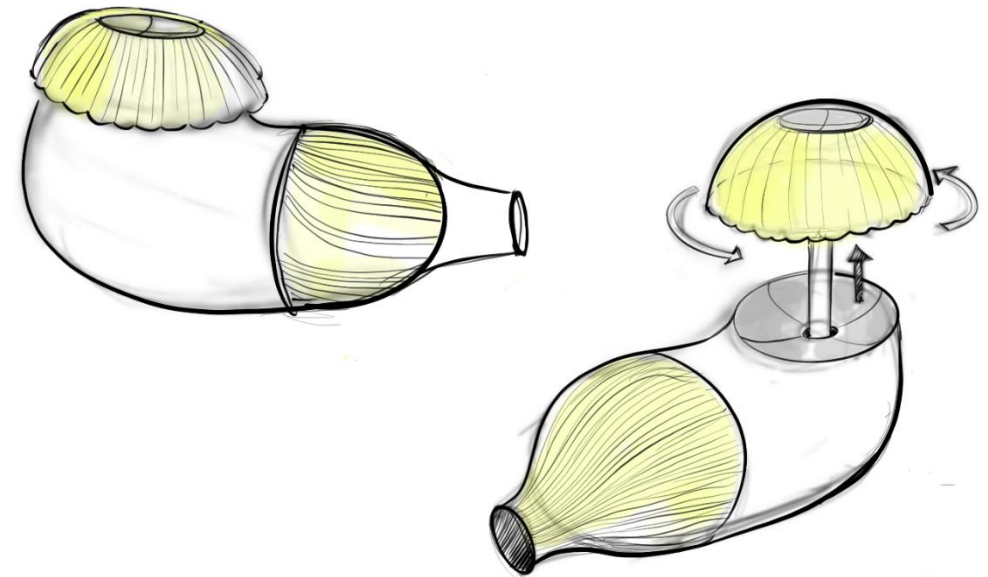


Figure 42 Ideation for playfulness

When blown out, the head will move up as well as spin in one different providing a visual treat

Ideations for Playfulness

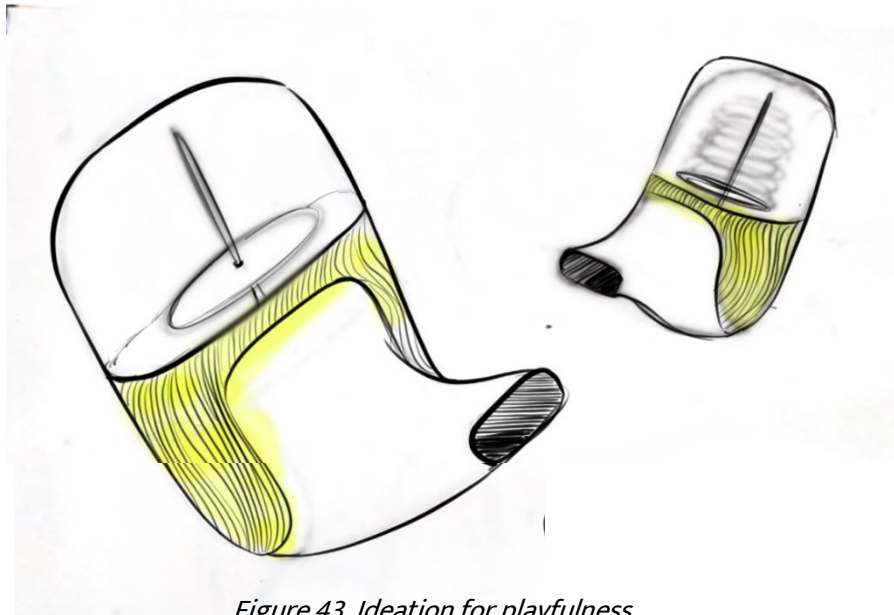


Figure 43 Ideation for playfulness

Spin and reach it to the top, that will be the target for the kids; To blow hard and spin the colourful coin inside the device, help it reach the top

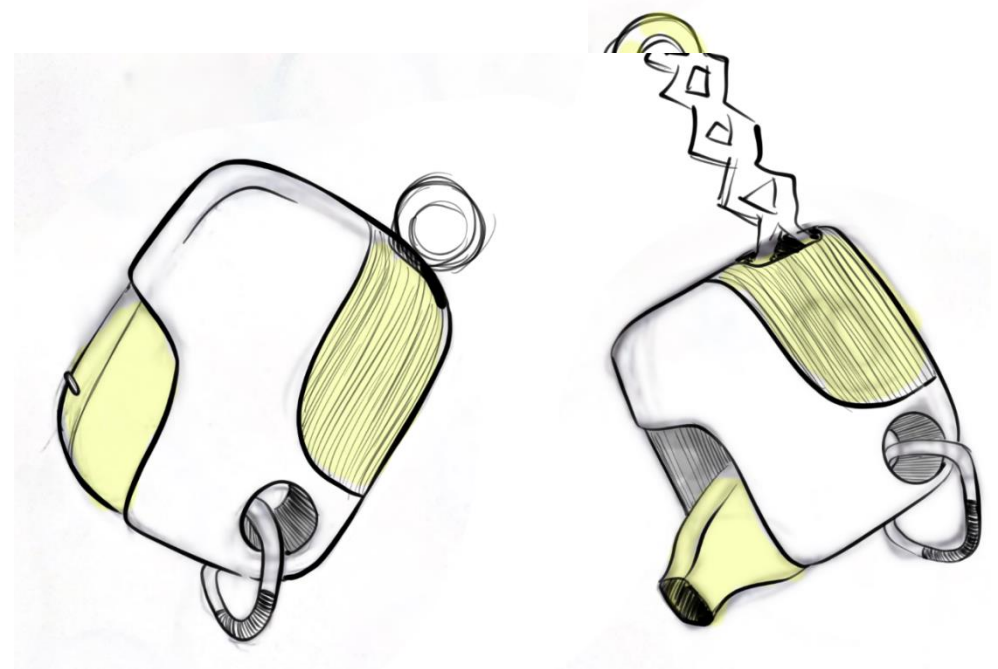


Figure 44 Ideation for playfulness

Compact form in which the user can flip down the mouthpiece to use, blow out hard to project the ring up.

9. Concept

9.1 Concept 1

Task: Kid can blow in an out easily through the mouth piece by lifting the upper globe ,hence making the mouth piece's pathway clear for accurate testing

Exercise: while the globe is placed down the turbine enters the mouthpiece , hence when blown the fan operates creating a visual treat

Form :The form is a globe shape with a textured handle for better grip

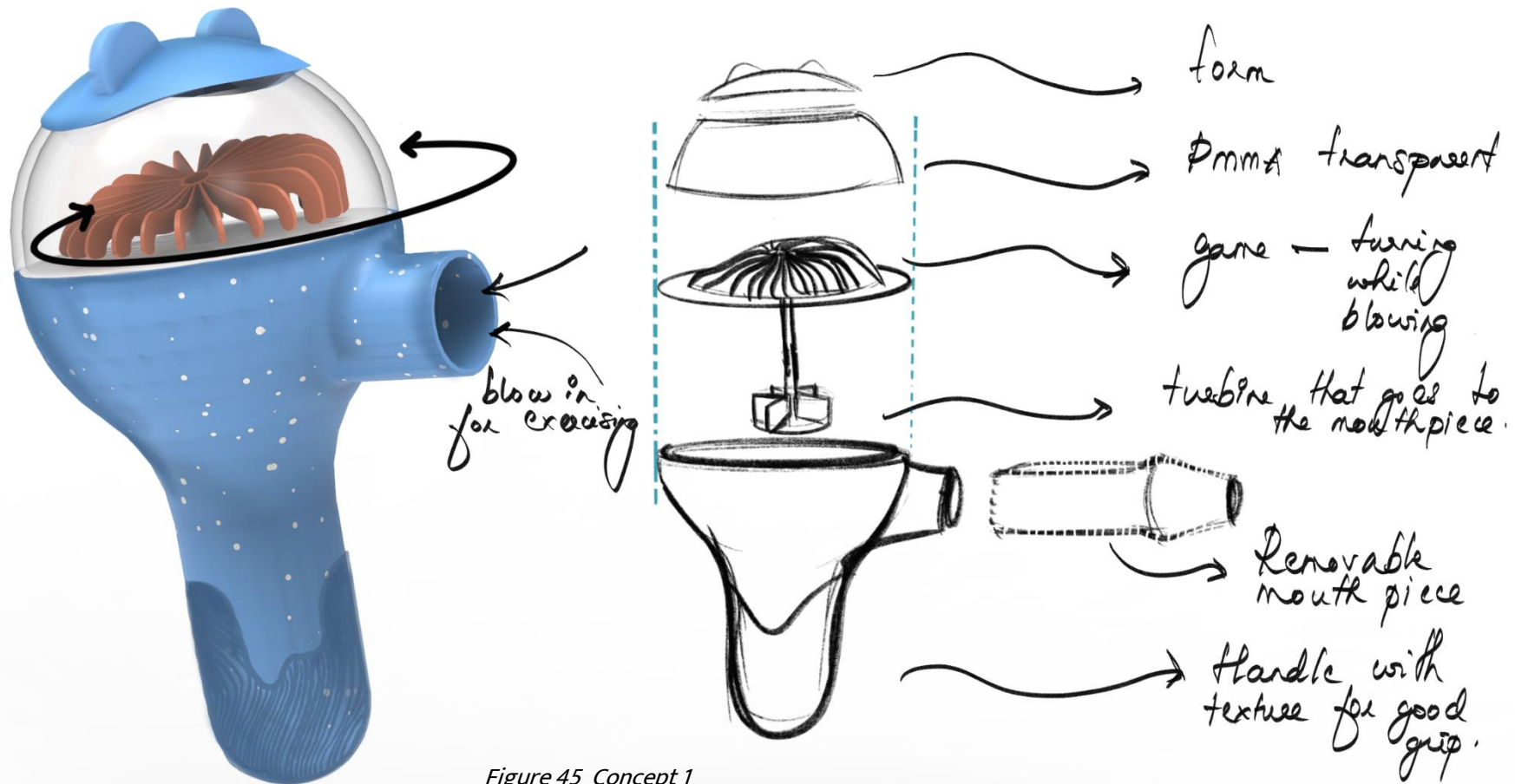


Figure 45 Concept 1

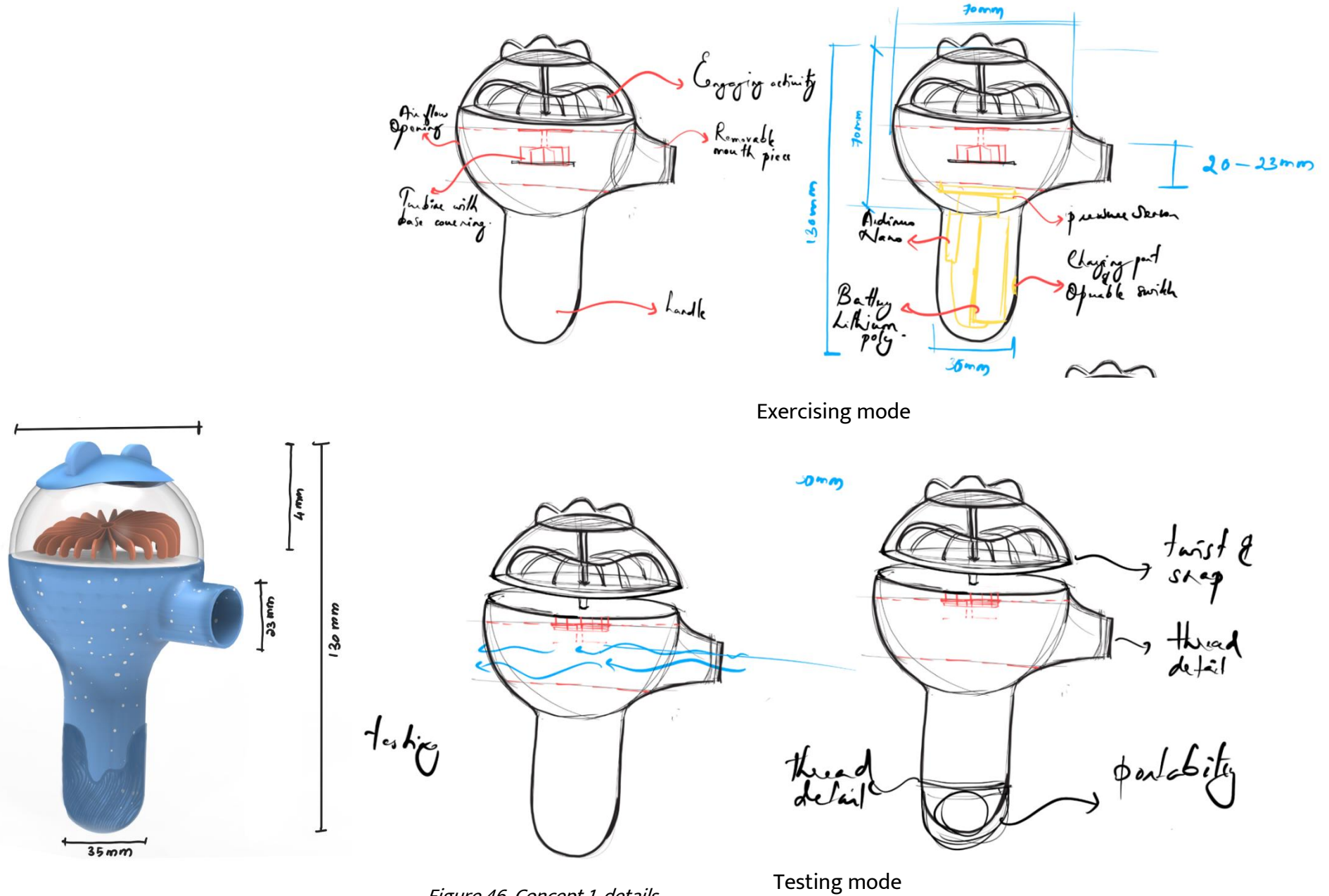


Figure 46 Concept 1 details

9.2 Concept 2

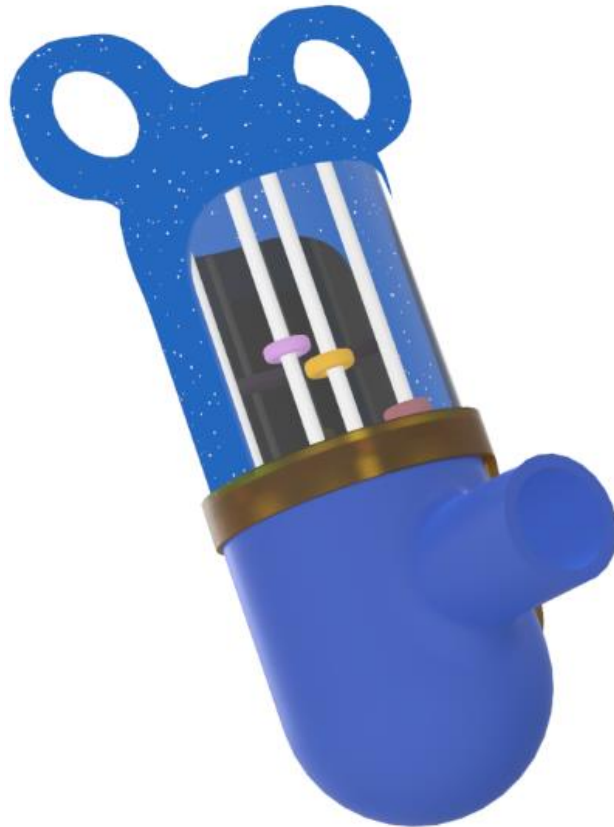


Figure 47 Basic form – Concept 2

Task: Kid can blow in and out easily through the mouth piece for conducting the test

Exercise: Turn the red middle portion to cover the air gap, then blown in for activating the game, targeting to reach the rings to the top most portion of device

Form :The form animal inspired form

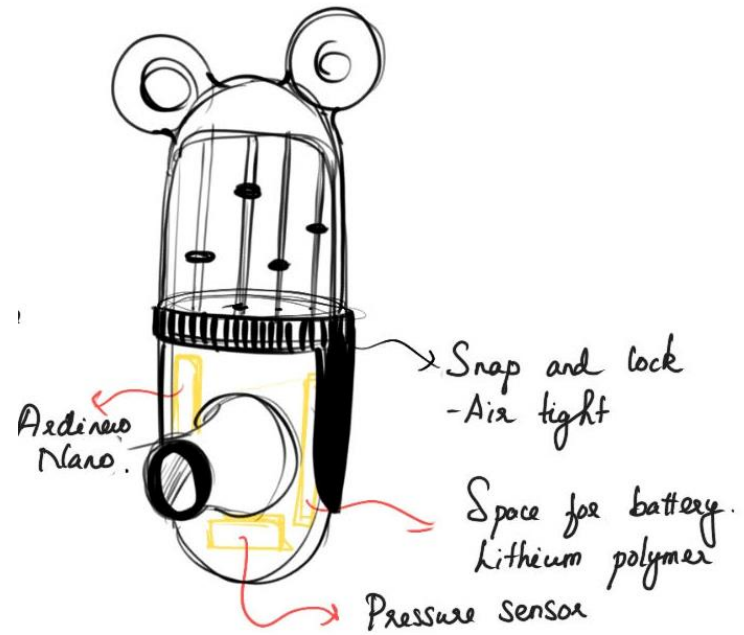
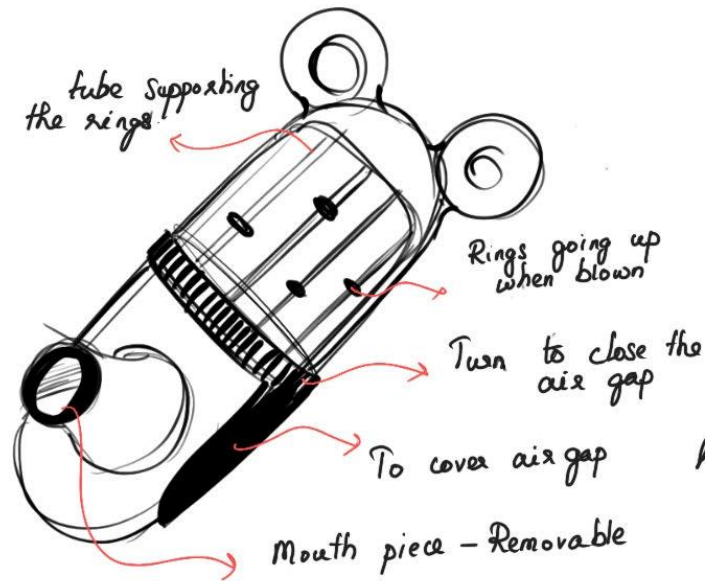


Figure 48: Details

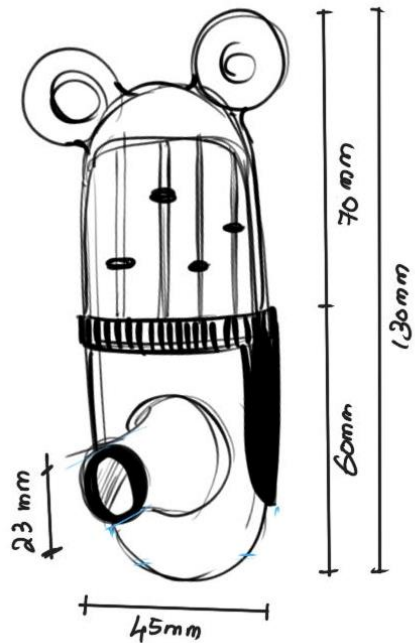


Figure 49: Dimension

9.3 Form explorations

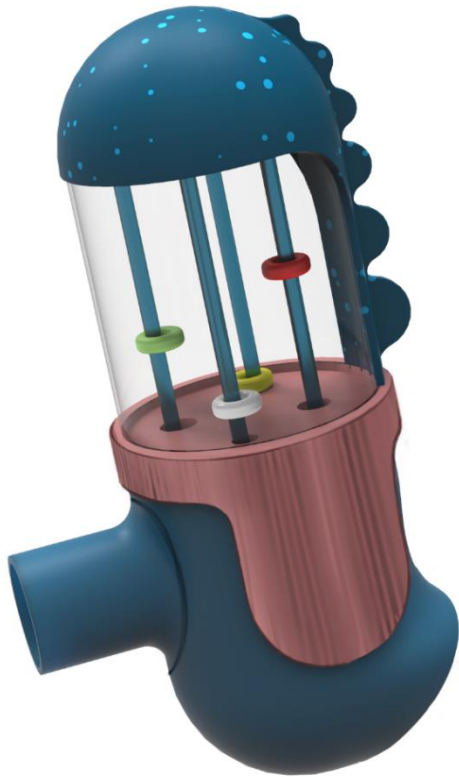


Figure 50: Animal inspired form

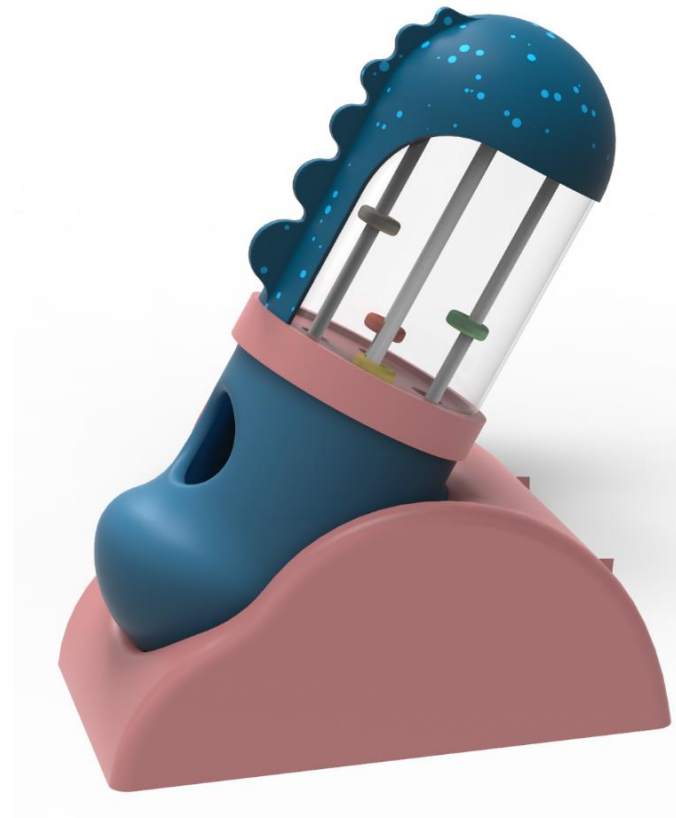


Figure 51: Product with stand

Stand for resting the device in such a way that the mouth piece is covered and safe from dust.

Dimension drawing

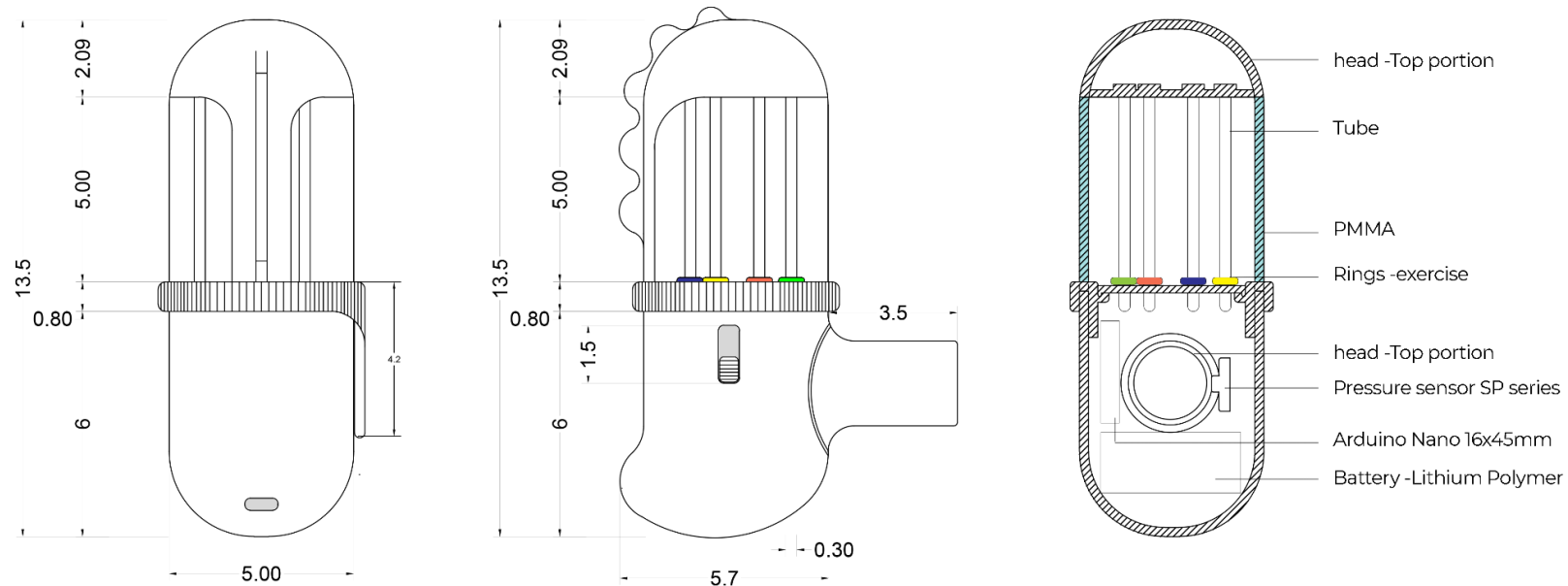


Figure 52: Product Dimensions

Activities

- Lung capacity test
- Exercise

- Incorporating testing and exercise into one product so that it help children to learn the testing process easily, make them feel more connected to it and thus increase the frequency and accuracy of the test.
- Playfull game
- Removable and washable mouth piece

Material - Polypropylene, PMMA
 Components - Top Body, Bottom body, Middle body, Pressure sensor, Battery, Arduino Nano , Charging port
 Manufacturing- Injection molded parts

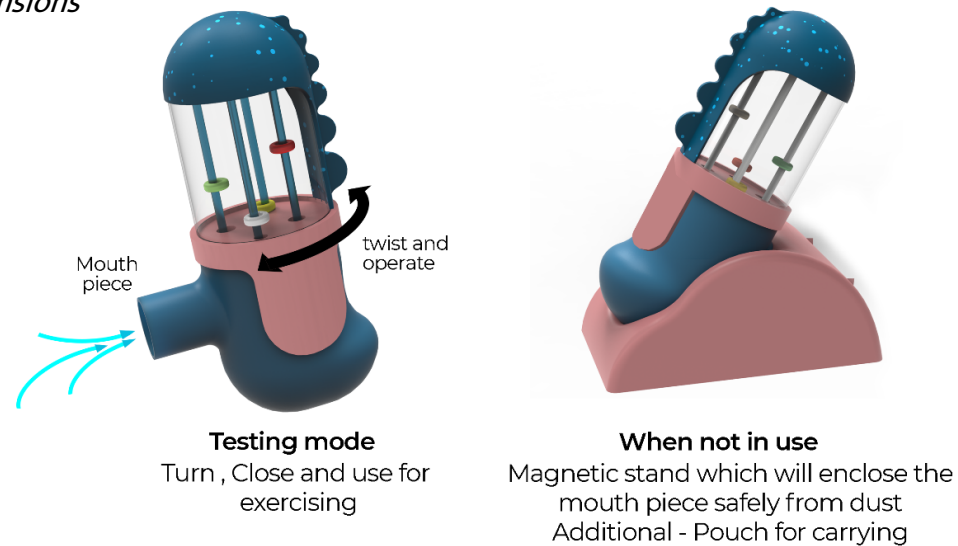


Figure 53: Product Details

9.3 Form explorations

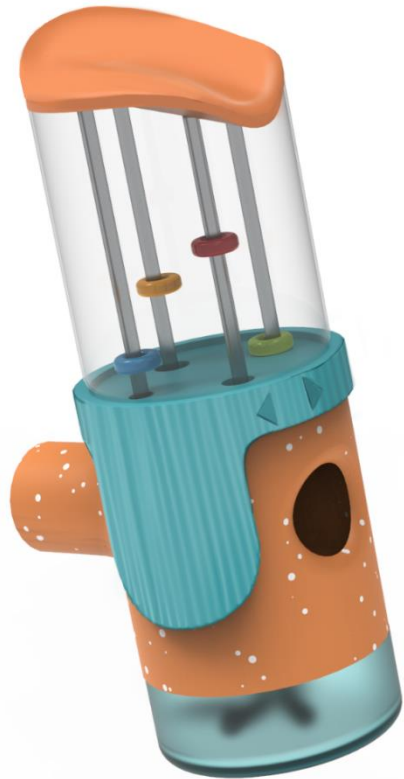


Figure 54: Form exploration

Form with an extra medicinal compartment that can help the user /caretaker carry their medicine while travelling

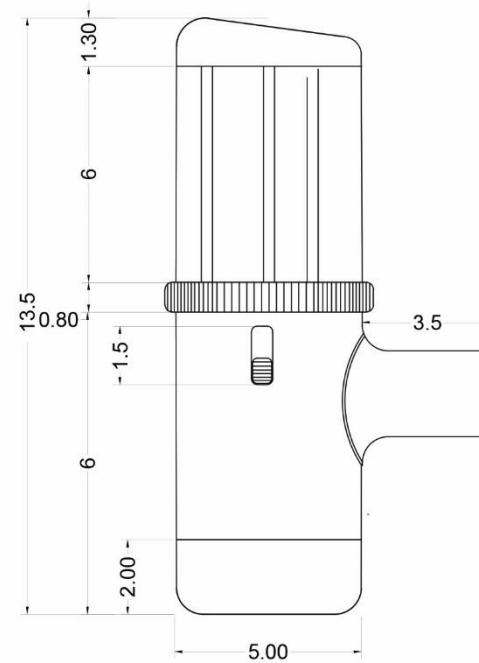
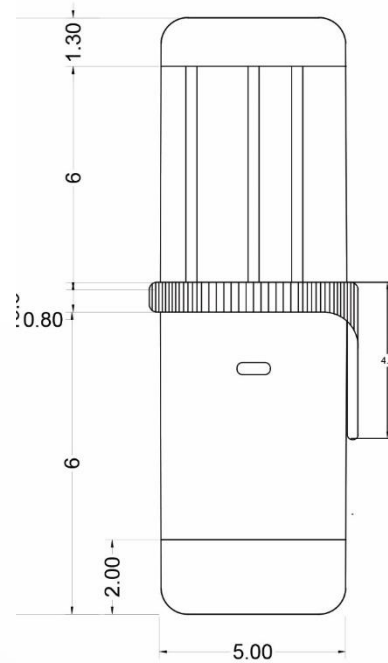
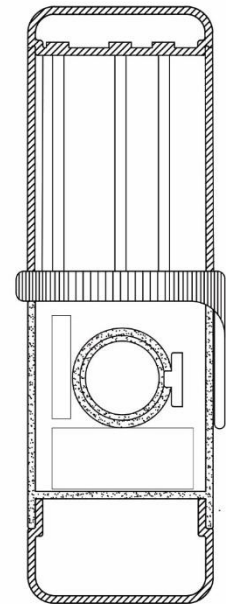


Figure 55: Dimensions



9.4 Mouth piece – User testing



Figure 56 , Safety measures taken for user testing with kids

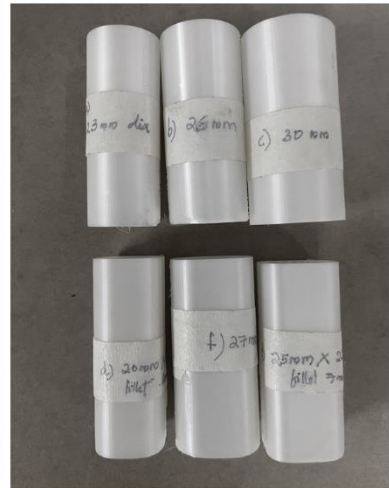


Figure 57: Mouth pieces of different size shape , with different fillets



Figure 58: Kids trying out different mouthpieces



Figure 59: Most comfortable mouthpiece for kids- 25mmX 22mm, 7mm fillet

9.5 Forms – User testing



Figure 60: User testing with forms

9.6 Final Concept 2

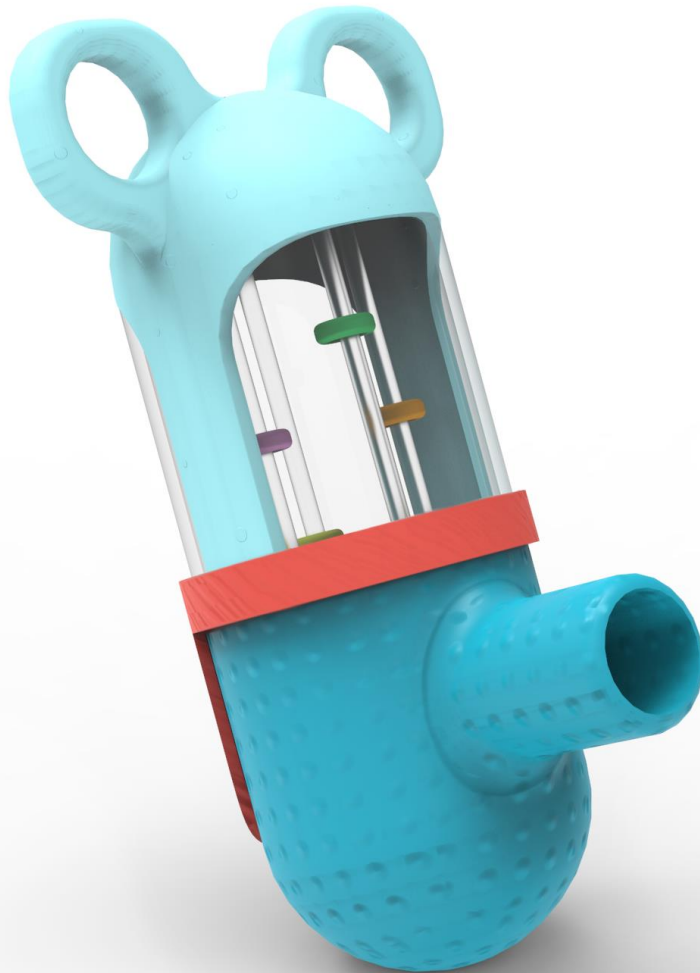


Figure 61 :Basic color scheme and form

Task: Kid can blow in and out easily through the mouth piece for conducting the test

Exercise: Turn the red middle portion to cover the air gap, then blown in for activating the game, targeting to reach the rings to the top most portion of device

Form :The form animal inspired form

9.7. Dimensional drawing

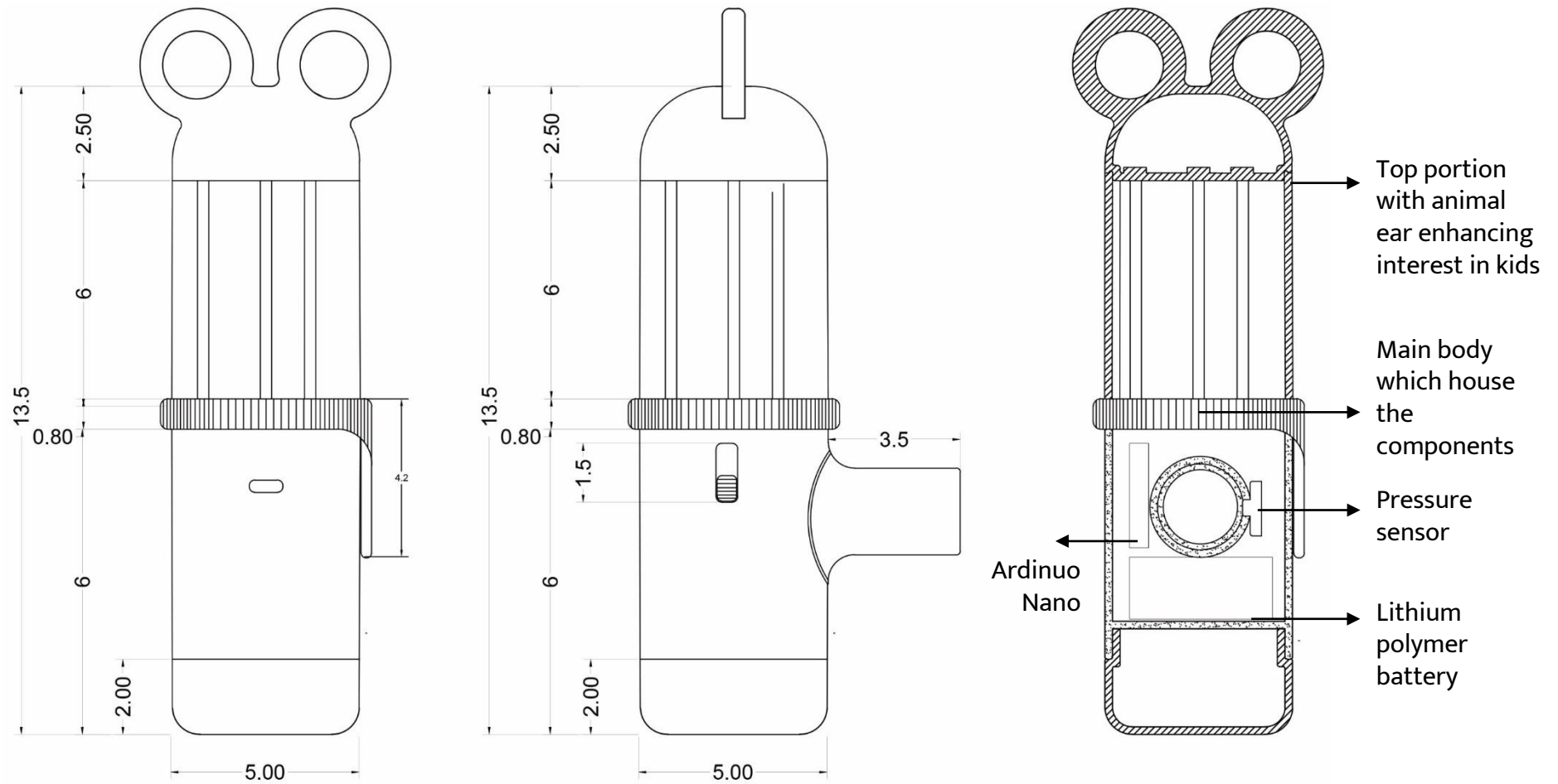
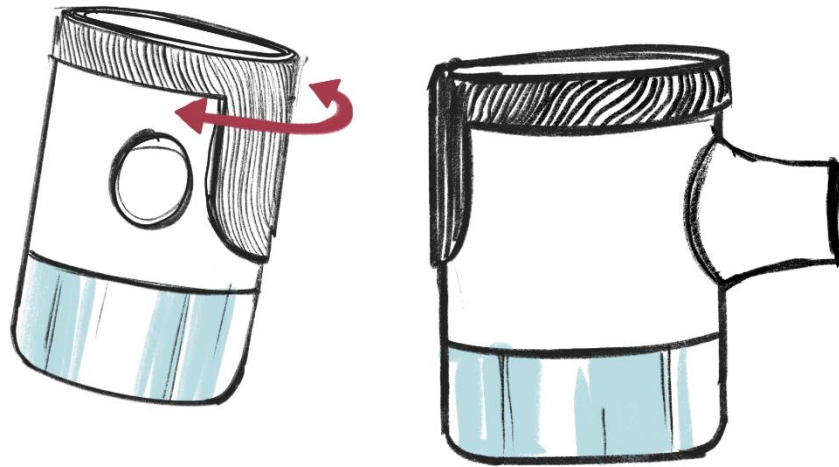
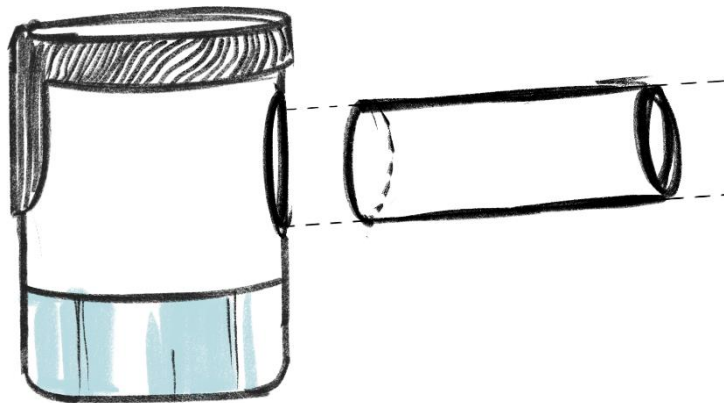


Figure 62: Final concept dimensions and section

9.9.Final concept Details



Twist to close the air gap and use it for exercising



Removable mouth piece for washing

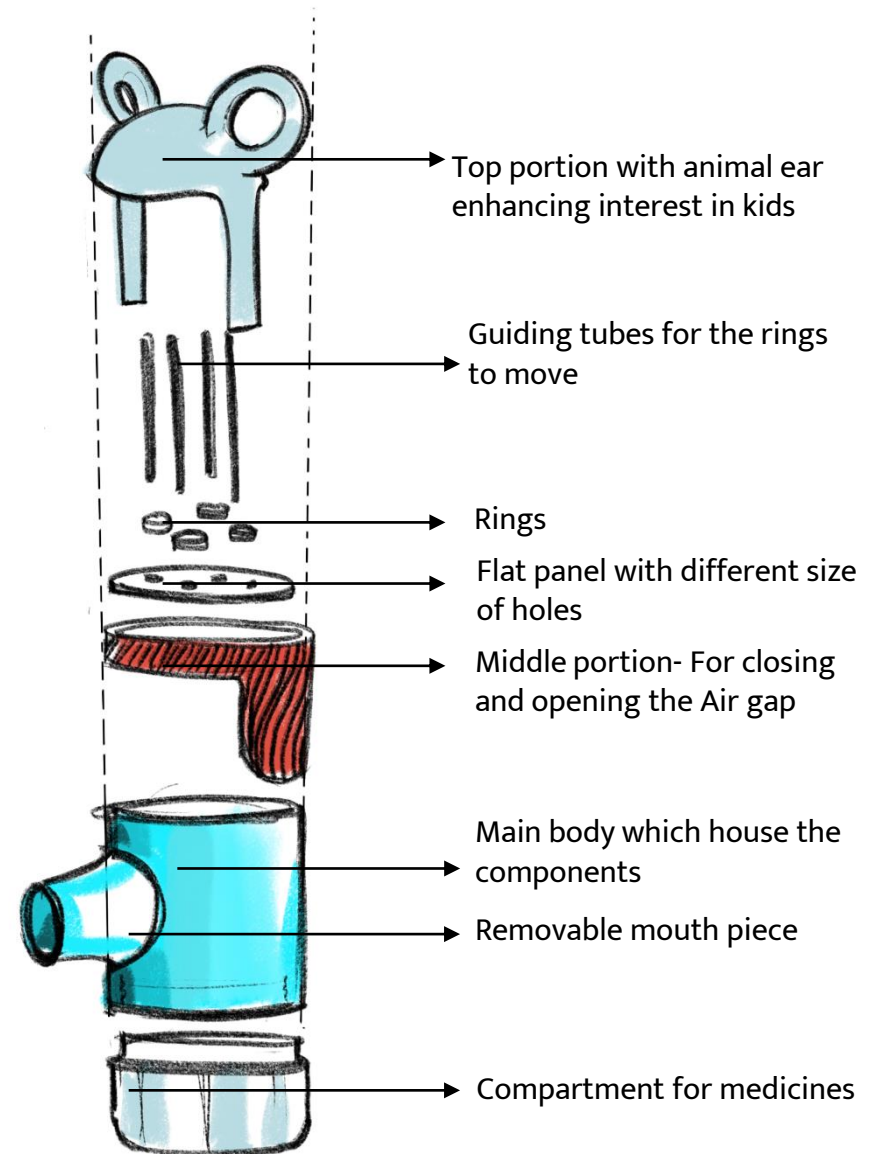
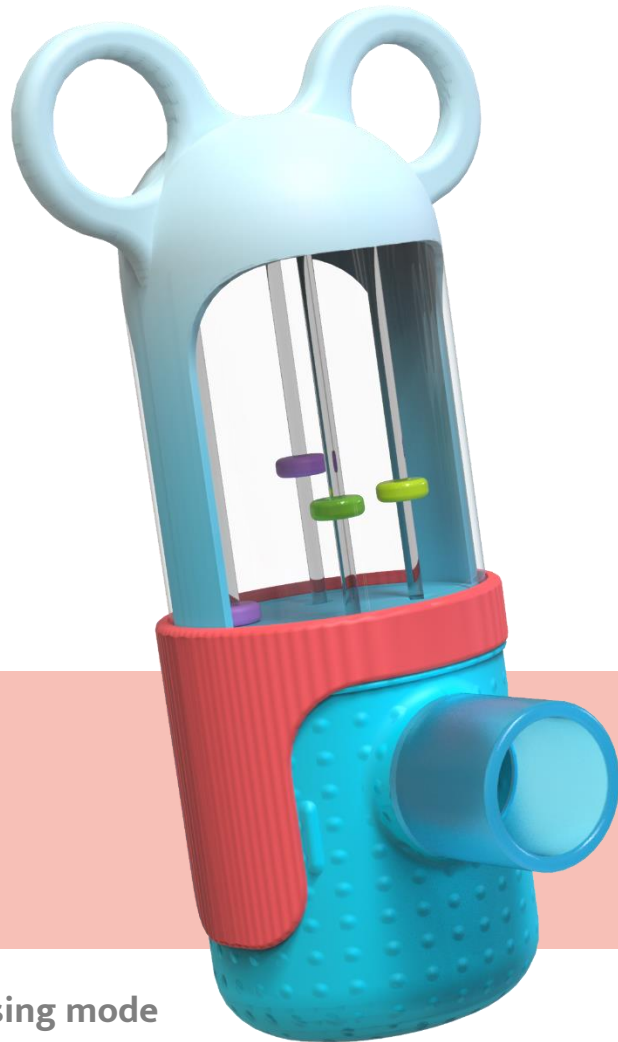
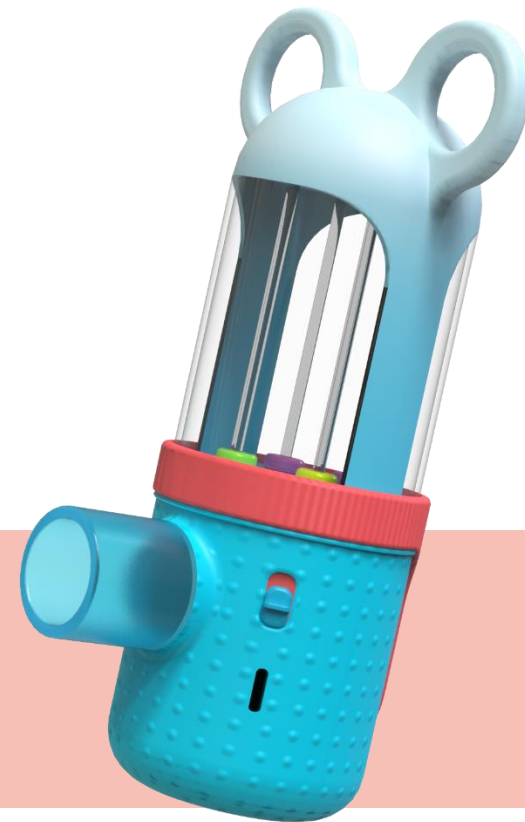


Figure 63: Final concept details

10. Phoo

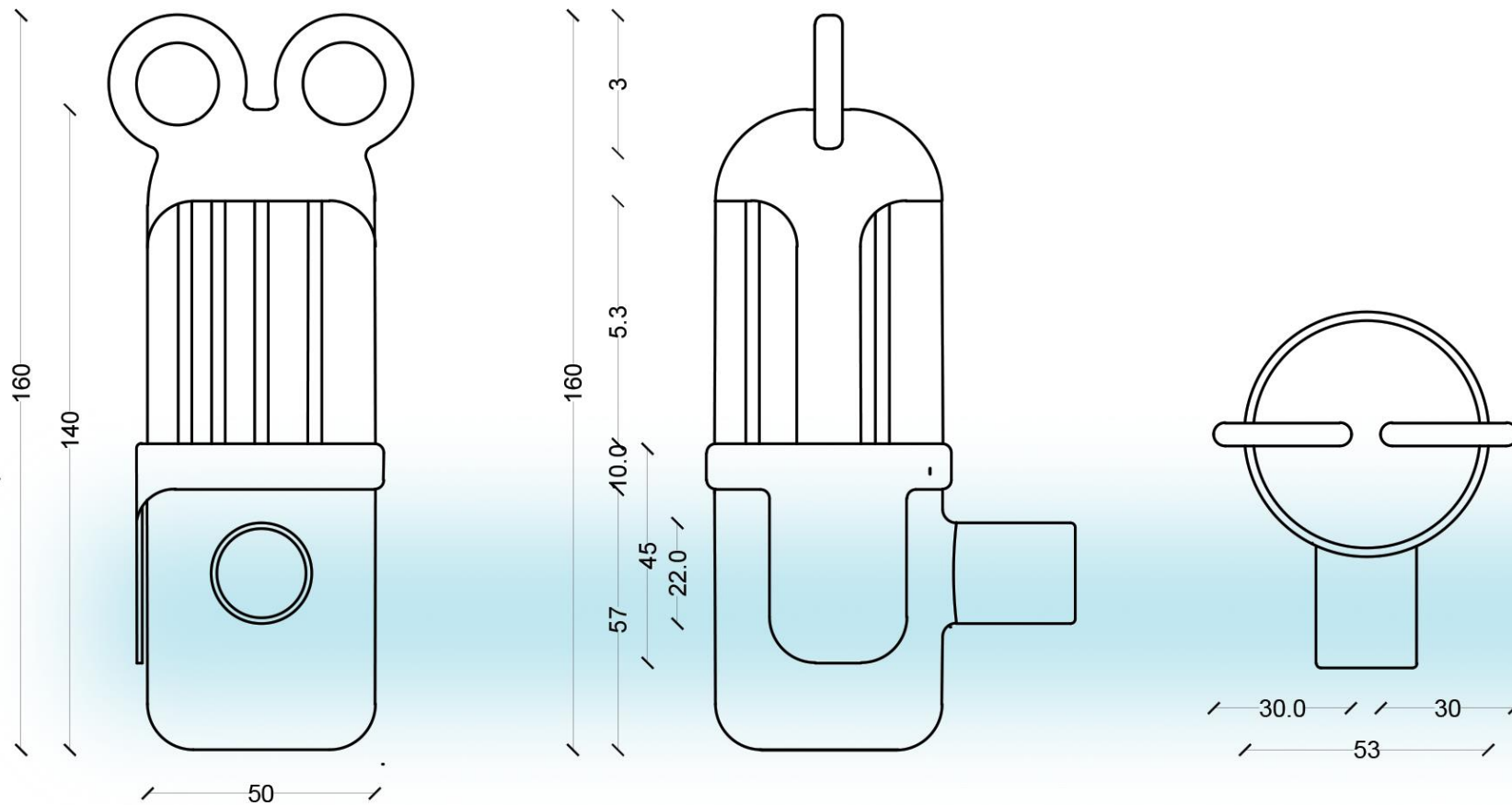


Exercising mode

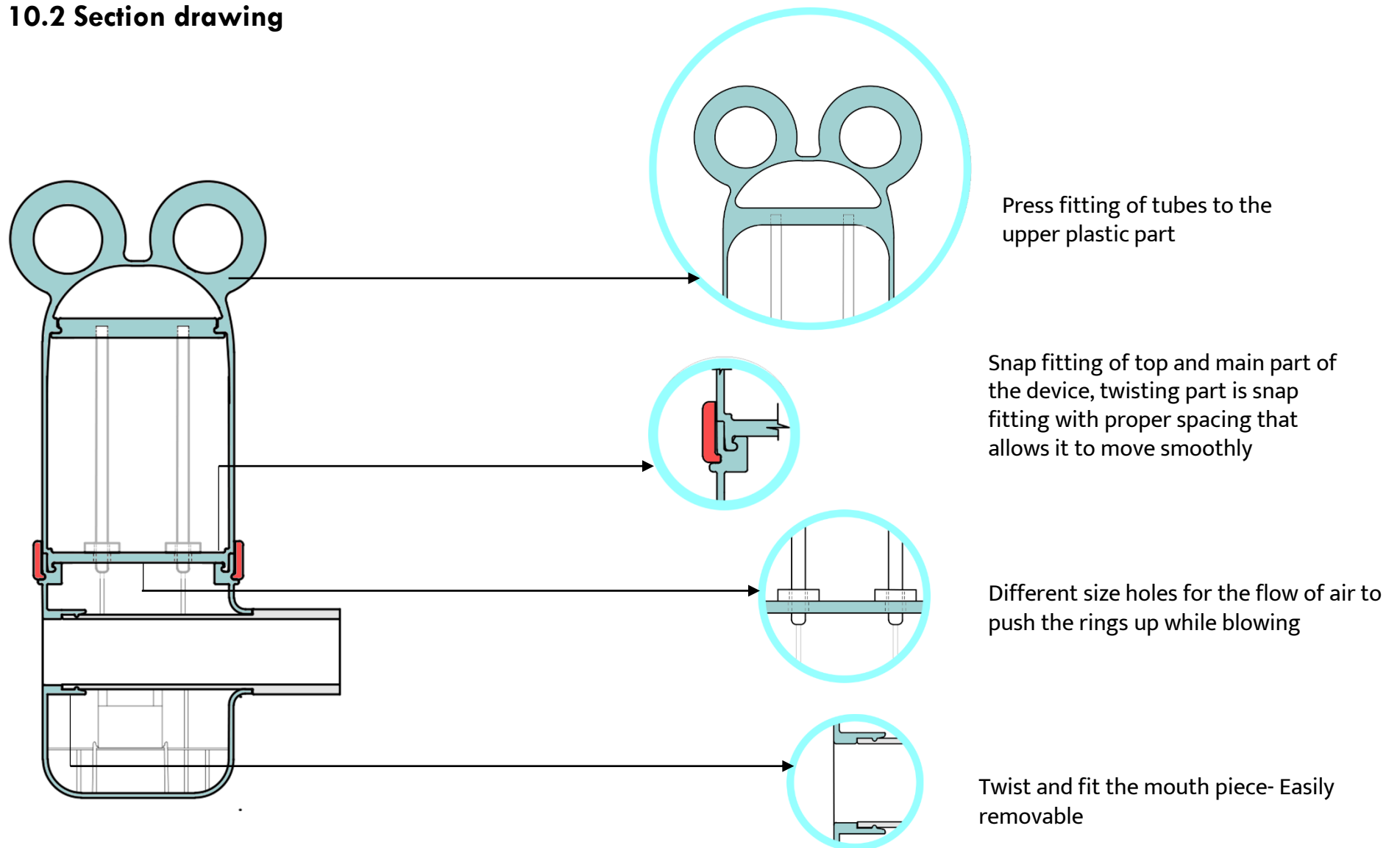


Testing mode

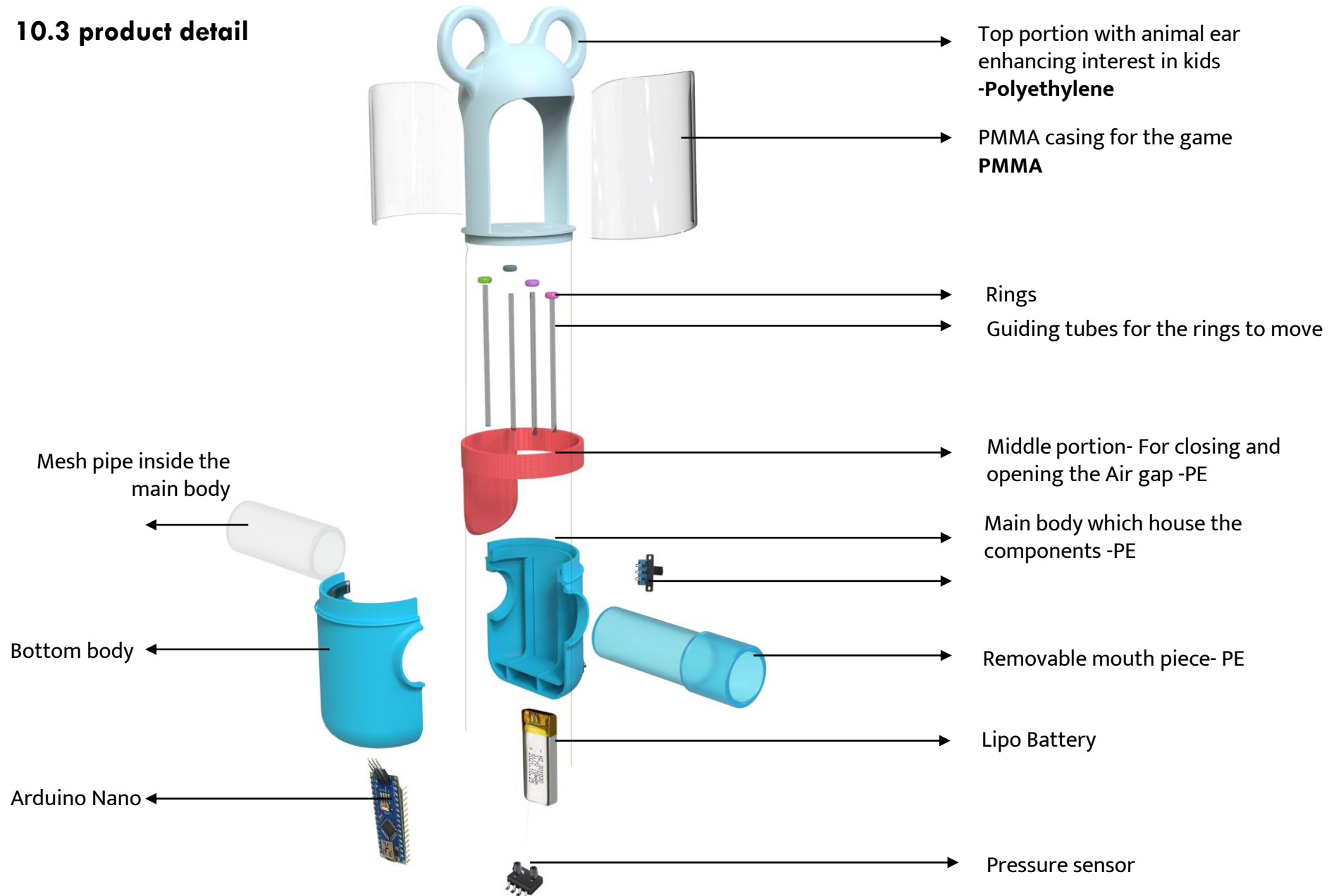
10.1 Dimension drawing



10.2 Section drawing



10.3 product detail

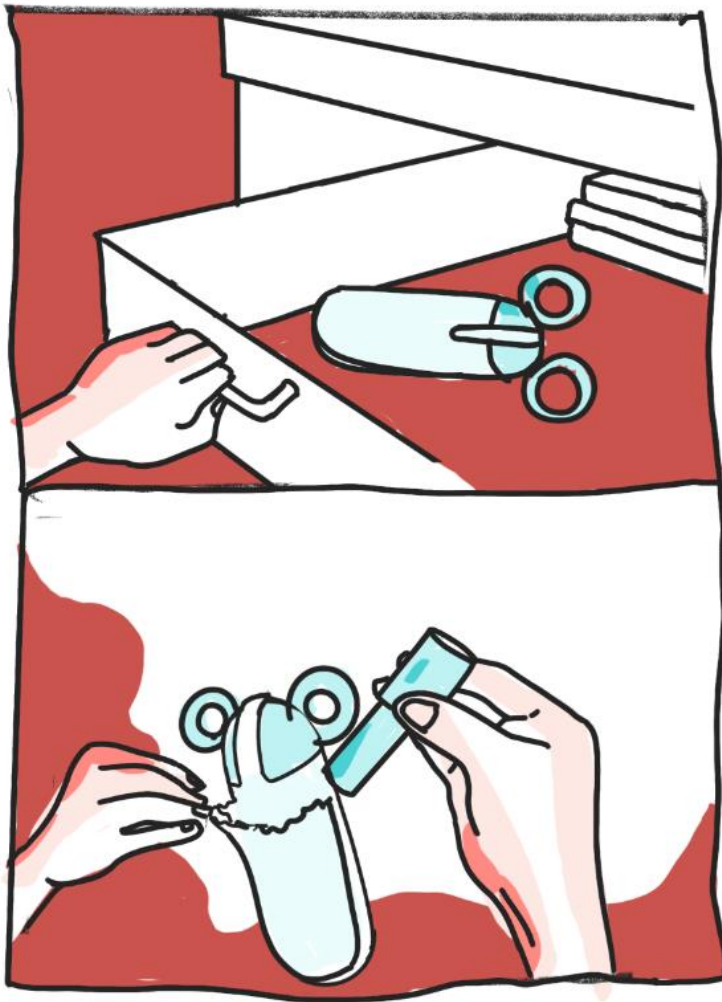




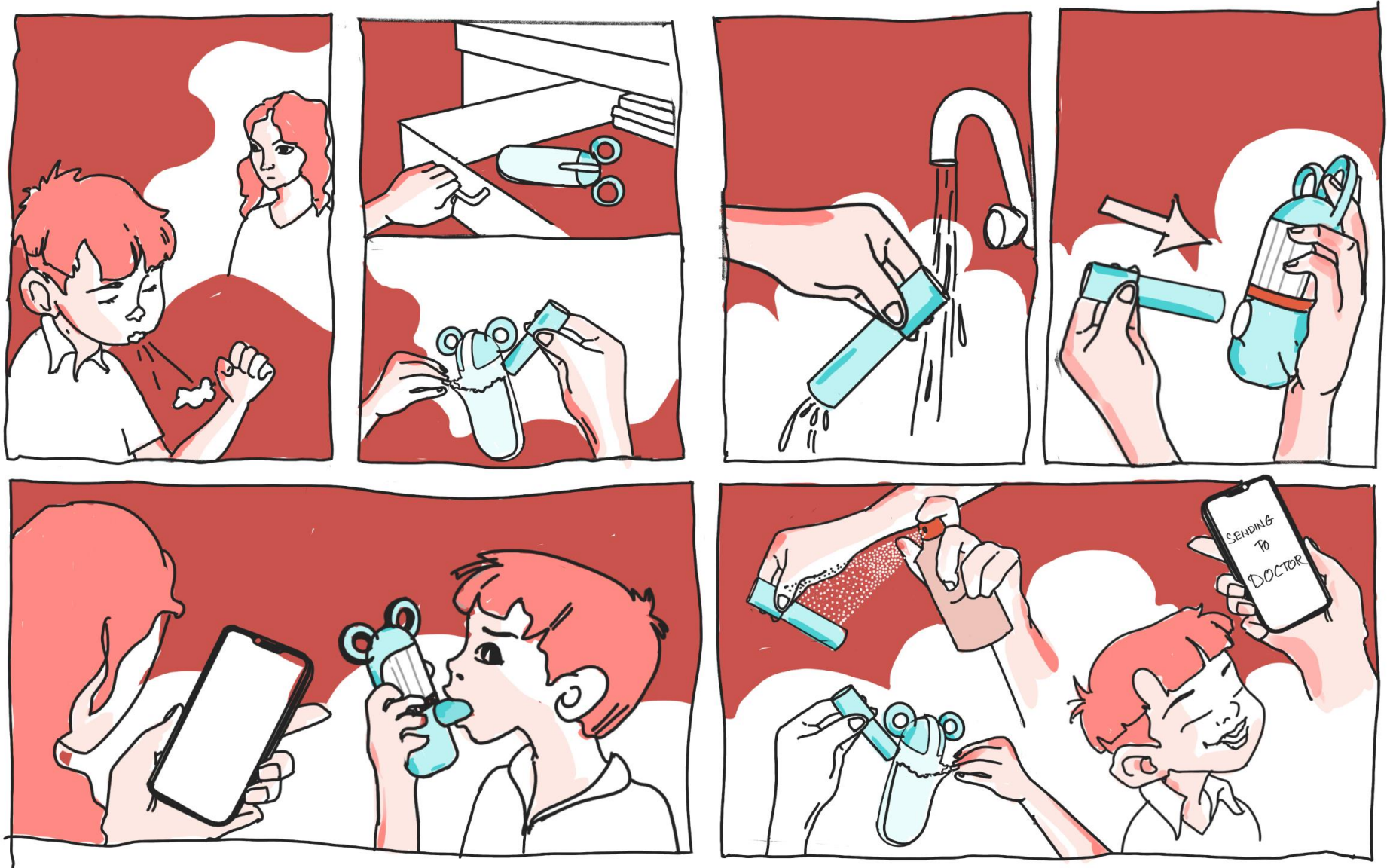




10.4 product storing



10.5 user scenario



10.6 Packaging





10.7 Prototype





phoo
User manual

phoo

2 modes

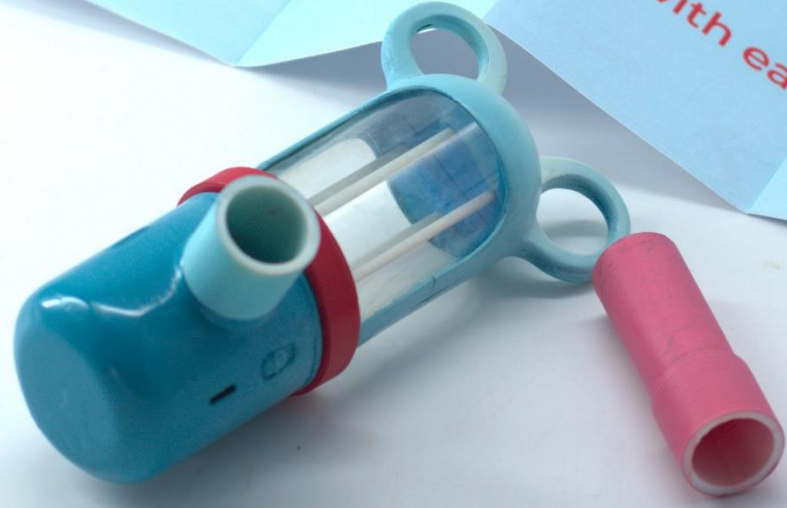
A Complete Solution for Respiratory Health!
• Lung Exercise
• Lung Testing





Access wellness with ease
😊

phoo
User manual



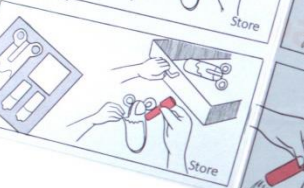
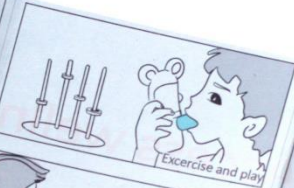
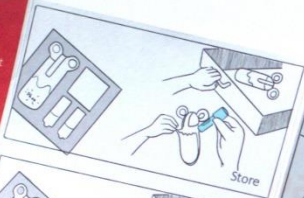


**Mode 1
Lung exercise**

Engage in lung exercise by blowing through the mouth pipe and aim to elevate the beads as high as possible. Set targets each time to track progress and witness improvement over time.

**Mode 2
Lung Testing**

Blow in and out through the mouth pipe swiftly until the app displays a successful reading. Download or send test results directly to your doctor for analysis.



10.7 User testing and validation



Usability

- Smoothly moving part
- Stopper need to be improved
- Good gripping

Hygiene

- Easily removable,
- Suitable size for all ages between 5-19
- Easily washable

Form

- Interesting form
- Unisex interest in the form and color
- Engaging and functional game





Thank you

10. Reference

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6442789/>
<https://designawards.core77.com/Commercial-Equipment/49132/VitaBreath>
<https://www.connecticutchildrens.org/health-library/en/teens/use-incentive-spirometer/>
<https://www.rapiddirect.com/blog/medical-grade-plastics/>
<https://bmpmedical.com/what-plastics-are-used-in-medical-devices/#:~:text=Polypropylene%20is%20a%20cost%2Deffective,cycles%20it%20can%20be%20reused.>
<https://pharmaceutical-journal.com/article/ld/chronic-obstructive-pulmonary-disease-diagnosis-and-management>
https://b-arm.com/product/smart-one-spirometer/?gclid=Cj0KCQjw54iXBhCXARIsADWpsG_loNC4q6h0Gxi5aUGvnh6IUo9u07zjv8JC2kXktobZuQ8uVLbDlSkaAqDuEALw_wcB
<https://www.medicaldevice-network.com/comment/vital-signs-medical-devices/>
<https://www.nature.com/articles/nnpjcrm201636#:~:text=The%20use%20of%20spirometry%20in,of%20spirometry%20in%20clinical%20practice.>
<https://www.cipla.com/our-offerings/our-therapies/respiratory/copd>
<https://kidshealth.org/en/teens/use-incentive-spirometer.html>
<https://www.rediff.com/news/interview/ccopd-2nd-biggest-cause-for-deaths-in-india/20190205.htm>
https://journals.lww.com/lungindia/Fulltext/2021/11000/Prevalence_of_chronic_obstructive_pulmonary.2.aspx?WT.mc_id=HPxADx20100319xMP#:~:text=The%20random%2Deffects%20pooled%20estimate,95.5%25%20and%20P%20%3C%200.001.
https://www.colmed.in/contec-desktop-spirometer-sp100a.html?gclid=Cj0KCQjworiXBhDJARIsAMuzAuwjy8rR3aY12xNBWLI-uq9JjngkrOg2GI4V1eYxOtkEtM7IaUhrWj4aAswPEALw_wcB
https://respbuy.com/product/rms-helios-401-spirometer-pft/?gclid=Cj0KCQjworiXBhDJARIsAMuzTEFFotCEEntHgoEZ7b4ZfLVNO4mxkVMKV093LU_FoGrZD_gBj-YaAj3NEALw_wcB
<https://www.healthline.com/health/incentive-spirometer#who-needs-it>
<https://covid19.nih.gov/news-and-stories/monitoring-lung-function>
https://www.researchgate.net/publication/7332510_Lung_functions_with_spirometry_An_Indian_perspective-II_On_the_vital_capacity_of_Indians
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6489506/#:~:text=Spirometry%20is%20one%20of%20the,spirometry%20in%20a%20scientific%20manner.>
<https://www.inofab.health/product/spirocloud?hsLang=en>
<https://healthfully.com/calculate-results-spirometer-lab-12114696.html>
<https://breathe.ersjournals.com/content/8/3/232>
<https://www.blf.org.uk/support-for-you/breathing-tests/spirometry-and-reversibility>
<https://drpremmaurya.in/spirometry-dlco.php>
[https://www.thelancet.com/journals/langlo/article/PIIS2214-109X\(18\)30409-1/fulltext#seccestitle10](https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(18)30409-1/fulltext#seccestitle10)
<http://fabacademy.org/2019/labs/bahrain/students/zahra-almukhariq/projects/final-project/>