

BAMBOO BICYCLE FOR CHILDREN

MOBILITY & VEHICLE DESIGN PROJECT II

MVD II -30

BY

NIKHIL KUNNATH

146390007

GUIDE: PROF. NISHANT SHARMA



INDUSTRIAL DESIGN CENTRE
INDIAN INSTITUTE OF TECHNOLOGY
BOMBAY 2016

Declaration

I declare that this written submission represents my idea in my own words, and where others' ideas or words have been included, I have adequately cited and referenced the original source. I also declare that I adhered to all principles academic honesty and integrity and have not falsified, misinterpreted or fabricated any idea/ data/ facts/ sources in my submission. I understand that any violation of the above will be cause for disciplinary action by the institute and can also invoke penal action from the sources from which proper permission has not been taken, or improperly cited.

Signature:



Name: NIKHIL · K · S

Roll no: 146390007

Date: 28/12/15

Approval Sheet

This Mobility & Vehicle Design project report titled Bamboo bicycle for children by Nikhil.K.S is approved in partial fulfilment of the requirements for Master of Design degree in mobility and Vehicle Design.

Project Guide :

Chair Person :

Internal Examiner :

External Examiner :

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Last but not least, I would like to thank my family, all my friends at IDC and outside and the children of the IIT Campus School for being constant source of support and inspiration throughout the project.

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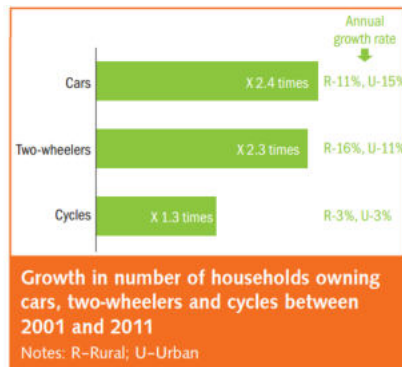
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1. Introduction

Bicycles have been in use around the globe for a long time now. They probably are the most affordable means of personal transportation available to mankind. Despite being so, the growth in number of people owning one is very less when compared to other motorized means of transportation like cars, bikes & scooters. One major cause for the slow growth rate is the rise in price in the recent years due to various supply chain issues.

But despite the rise in price there still is a slow consistently growing demand for bicycles in the country both in urban and rural environments. Children being one of the major reasons for that demand. Bicycles are one of the most prized possessions a child can have which helps in their personal transport. The joy and thrill of motion is one fascinating gift which the bicycle promises. And children try to get them whenever a chance comes.

The current bicycle industry is addressing the growing needs of the people in production numbers. But with more production numbers comes more unused & unprocessed wastage depositing up. These deposits will remain untouched in the environment for years as we experience it now, unless proper processing units come.

1.1. Scope of the project

Materials used on bicycles have evolved over the past will still continue to do so. Mechanical Strength is a natural property of a range of other materials also, Bamboo being one of them. The fact that bamboo being a natural and renewable resource, the value a cycle possesses can change if they are built using them.

With only conventional machineries required to process bamboo & spares being available in the market, bicycle production can be made cheaper. It can be made available to each and every doorstep where they can even be made by the family. Through which bicycles becomes priceless possession of human beings.



2. Why Bamboo?

Growth & Abundance

Bamboo is the fastest growing biomass, thus making it a widely available raw material. India has the second largest bamboo resource with over 136 species, 23 genera spread across 13.96 million hectares of land in the country. Bamboo can grow up to 8-10 feet tall in just 2 months of time and it grows on different soils in the country.

Craft Sustenance

Bamboo has been a part of India's culture & tradition from the past. Currently about 8.6 million people in India depend on bamboo for their livelihood through various craft and nurseries. Bamboo is also a unique material & demands adaptability during its processing due to unavailability of bamboo specific machineries. Hence craftsmen in the country has a potential to take a role in the production of these products and thereby have a better sustainable life.



Material capabilities

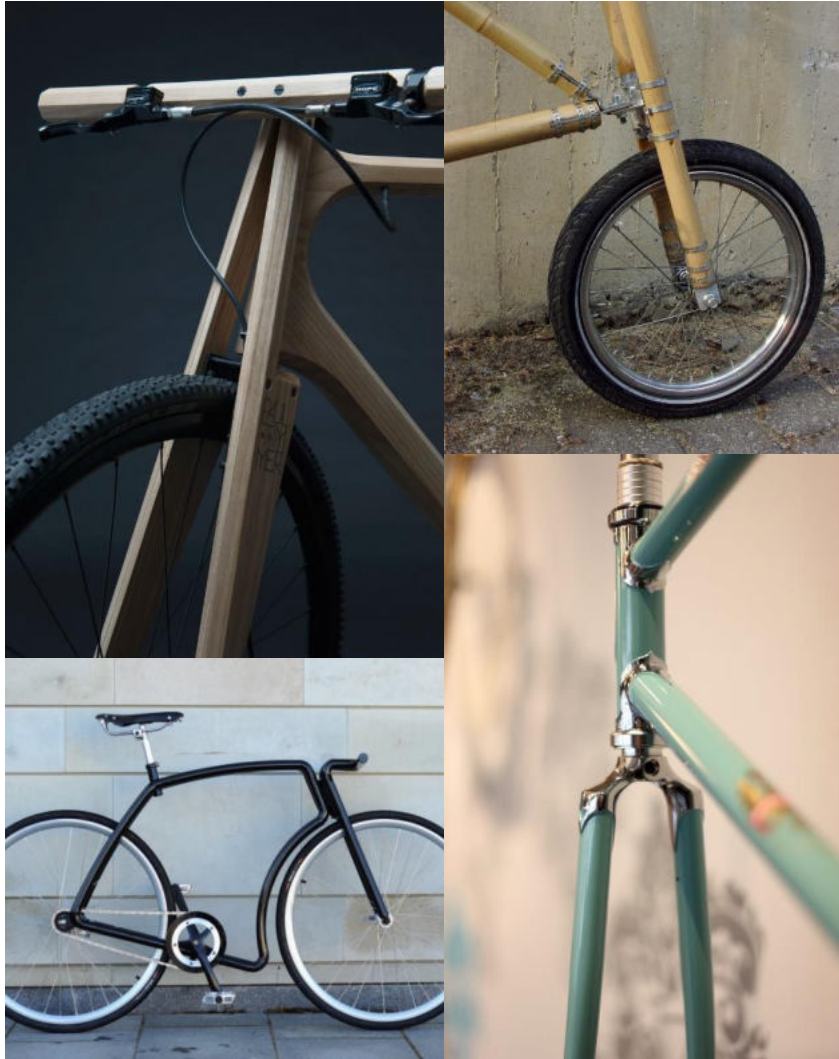
Bamboo has the unique combination of being light and voluminous at the same time. Bamboo offers a density of about 300-400kg/cub.m when compared to 7850 kg/cub.m of steel and 2712 kg/cub.m of aluminum. Compressive strength of bamboo is roughly between 40-80 N/sq.mm which is twice to four times the value of timber species.

The average tensile strength of bamboo is situated around 160N/sq.mm which is often 3 times higher than the most conventional construction grade timbers.

The bending strength of bamboo species varies between 50-150 N/sq.mm and is on average twice strong as most conventional structural timbers.

Renewable resource

In the current scenario, products are filling up the market. Synthetic and man made materials are clogging up after their usage without being recycled. The processing cost is also a factor for the above mentioned situation. Bamboo is a renewable resource and can be processed with the most conventional machineries available in the country.



3. Material study

Wood

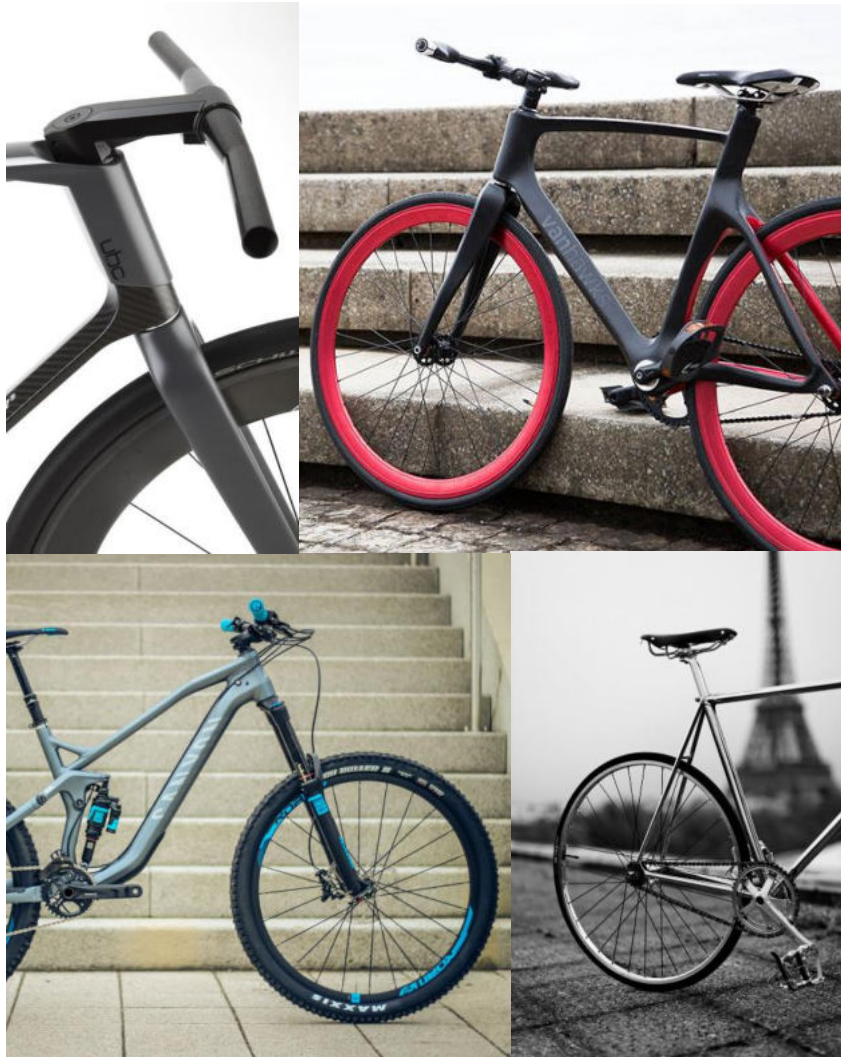
A natural material which has been used extensively in the past for various mechanical structures specially for furniture's. wooden bicycles have cleaner joineries and gives a feel of a monocoque frame when joined. Surface transitions are smooth on this material. It has the natural essence.

Bamboo

Bamboo has been used majorly in its naturally available form. This also has issues of getting standardized and hence bamboo bikes are not to be seen much. Mainly uses hemp and metal joineries. Surface transitions are not yet made use of on this material.

Steel

Most widely used material on bicycles. Tubular, planar & bent sections are used which are TIG welded in the current scenario .Lug fittings used at the joineries which gives a mechanical essence without any surface transition. Proportion and stance of the bicycle were vital elements. Use of paint and vinyl graphics over the material is extensive. Prone to corrosion.



Carbon fibre

The material with great strength which is extremely light and used quite widely in the automotive industry. The material is capable of sharp surface transitions and has a default texture to itself. The dark shade with the texture looks appealing to many vehicle enthusiasts. The material is joined by adhesives and lugs. Monocoque frames have been developed with this material

Aluminium

The growing material in the bicycle industry where a balance between all the qualities is possible. The material is light having a much lower density than steel and is also stiff at the same time. TIG welding is done commonly to join sections. The sections used is highly manipulative. AL6061 & AL7605 are two of the most widely used alloys of aluminium.

Titanium

The exotic and expensive class of material. The material displays excellent highlights and depths of light falling on it due to the material composition and texture

3.1. Inferences from the study

- Bamboo is a potential material for bicycle frames.
- Bamboo is available almost in the entire country with Northeast East Regions dominating. Hence the raw material for the Bicycle is Easily Procurable.
- It is also possible to grow bamboo as it can grow at a rapid rate and can grow on most Soils in the country. Which again adds to raw material procurement.
- Bamboo is cheap when compared to the other competing raw materials for bicycle.
- Bamboo exhibits both rigid and flexible properties depending on how they are used which can be implemented on the bicycle frames.
- Difficulty in standardizing sees bamboo cycles being produced in very low numbers.
- Through standardization of Bamboo as well as the handling equipment's, the final output can be increased in numbers. Thereby having a better source of income and hence living in a better way than the present scenario.



4. Trend analysis

Glimpse from the past- key events

- 1975 First carbon tubed metal lugged frame
- 1978 Folding clincher tire
- 1980 Aerodynamic road bikes 'Pinarello'
- 1981 Recumbent bikes by MIT
- 1983 Moulton space framed bikes
- 1985 Index shifting 'shimano'
- 1986 Lugged carbon frame TREK
- 1987 Full suspension mountain bikes
- 1994 Disc brakes

Current Trend

The current bicycle market in India has many foreign players. The common Indian brands being Hero, Atlas, BSA, Avon, Hercules who has to compete with the quickly growing foreign brands like Firefox, Trek, Montra, Schwinn, Schnell, Cannondale etc.

The foreign brands develop Light weight aluminum frame bicycles which are heavily loaded with the best in class components. These bikes are much aggressive & aerodynamic and have evolved to a much lower stance. The Mountain bikes having all the above mentioned characters is the booming market currently.



The Indian market tries to achieve all these standards in an economic way with the conventional steel tube frames without much care given to its design. The Indian brands are very rich in color and graphics which attract a lot of young crowd into that segment. The E-commerce segment is booming in the purchase of bicycles.

4.1. Inferences from the study

- Wide range of frameworks are & were available in the market. This is a motivation to explore the material.
- Need for design intervention when it comes to detailing of the frame .
- Foreign brands are way ahead in technology.
- Indian bicycles lack the aesthetics.
- A consistent demand for bicycles exists in the country and all across the globe.



5. Existing product study

Blackstar Ghana

Bamboo : natural form (cylindrical)

Supporting material : hemp & metal

Key point : Texture on the hemp joinery
Strength.

<i>Seat height</i>	<i>59 cm</i>
<i>Colors fenders, mudguard</i>	<i>Brown or White</i>
<i>Gears</i>	<i>Single Speed</i>
<i>Brake</i>	<i>Back paddle brake</i>
<i>Bottom brackets, hubs</i>	<i>Shimano</i>
<i>Saddle and grips</i>	<i>Brooks</i>
<i>Lock</i>	<i>ABUS</i>
<i>Front and Back light</i>	<i>LED</i>
<i>Weight</i>	<i>14 kilograms</i>
<i>Price</i>	<i>949,- EURO*</i>



Bamboo campos bikes - Spain

Bamboo : natural form (cylindrical)

Supporting material : carbon fibre & metal

Key point : clogging at joinery

Strength.

Use of color on joineries and accessories



T2o-scooter-bamboo by Antoine Fritsch

Bamboo : bamboo laminates/ply

Supporting material : cork, steel, aluminum, rubber

Key point : Clean joinery

Minimal

Quick assembly



Bamboo bee China

Bamboo : natural profile

Supporting material : steel & carbon fibre

Key point : Bamboo laminate rims

Quick assembly

<i>Bikes Frame</i>	<i>Honeywax Infused Technology</i>
<i>Handle</i>	<i>Classic Riser</i>
<i>Brake</i>	<i>Disc (Front)/ Roller (Back)</i>
<i>Tyre</i>	<i>700 X 28C</i>
<i>Rim</i>	<i>Bamboo Skin Lam Tec Aluminium</i>
<i>Gear</i>	<i>Shimano Nexus 3</i>
<i>Grip</i>	<i>Leather Handlebar Grip</i>
<i>:Saddle</i>	<i>Leather</i>
<i>Bamboo</i>	<i>Smoked Bamboo</i>
<i>Weight</i>	<i>13kg *with Coffee Wooden Crate</i>



Semester bicycle USA

Bamboo : bamboo thick laminates (hexagonal frame member)

Supporting material : steel

Key point : bamboo section

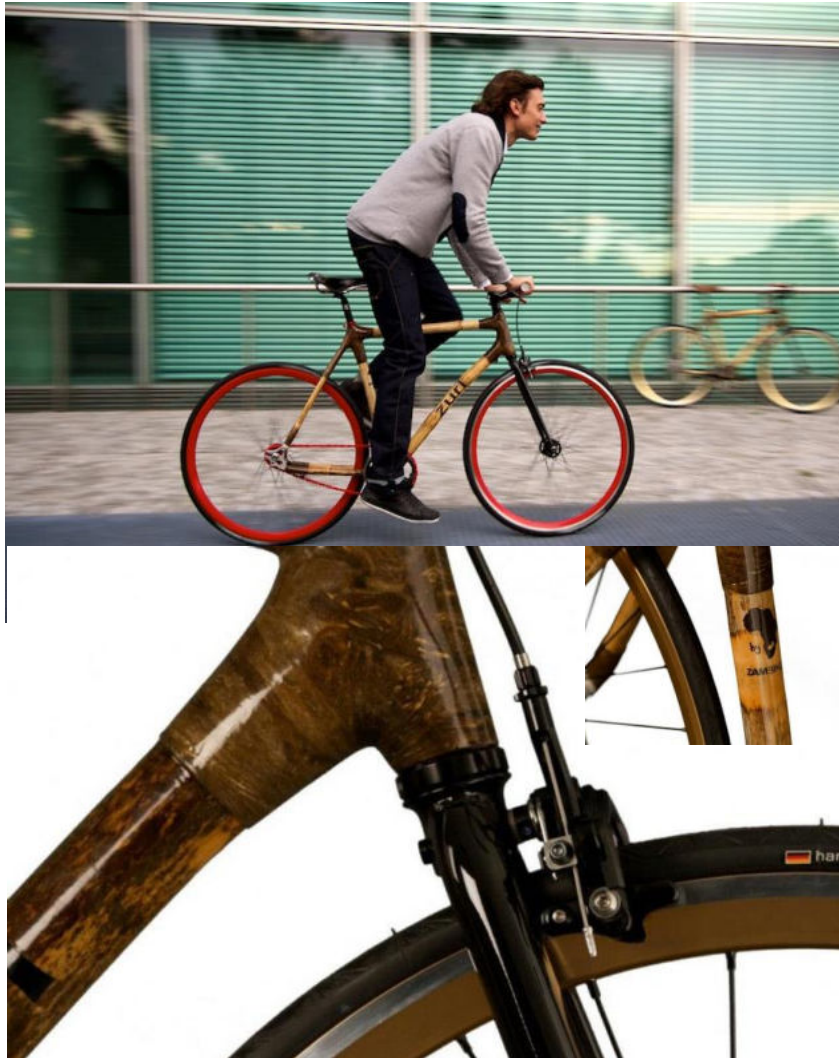


Bamboo bike by Ross Lovegrove

Bamboo : natural bamboo profile

Supporting material : aluminium

Key point : joinery through inner surface of bamboo
contrast of materials
surface quality



Zuri bikes Germany

Bamboo : natural bamboo profile

Supporting material : hemp and steel

Key point : bamboo section

Frame	zuri bamboo frame
Drive	Chain, front 2 -fold, 52 u. 39 teeth 10x (11-13-14-15-17-19-21-24-28)
Transmission	Shimano 105 ST 5700, 10x
Crank set	Shimano 105 FC 5750, schwarz
Saddle	fi'zi:k race saddle Arione Versus
Wheelset	Velocity "Deep V", 32 spokes black FW 32 radial, high flange hub HR 3-fold crossed, BLB Track hub
Weight	approx. 9,5 kg**
Brakes	Shimano 105 BR-5700
Tires	Schwalbe Durano S, 25-622

5.1. Inferences from the study

- Possibility to use bamboo in different ways to standardize the components without compromise in strength
- Possibility to use bamboo in the front forks of the bicycle.
- Need to have clean joineries.
- Color can be used over bamboo also to get an overall visual balance



6. User study

6.1. Behavioral study

The study was conducted during and after the festive season of Diwali in the IIT campus. The study was conducted to understand:

How children use their cycles

When & where do children take their cycles.

Key Observations

- Since it was the festive season of Diwali every one wore colorful attires and some even complementing the color of the cycle.
- Every evenings, Children gang up with their bikes and ride to and fro talking about many things.
- They test their cycles to all limits of riding.
- Not all children seems comfortable riding their bikes.
- Most children ride in groups of 2 or more.



Way to school

- Riding to school is not that simple as the child has to carry baggage's and also depends on the road conditions.
- Only few bicycles actually addressing riding posture.
- It is not always that children pedal the cycle. They also walk with their friends keeping the bicycle with them due to various reasons.
- The friendship and care for their beloved is also visible through the way they use their bikes and Indian market addresses the need.



Bike Customization

- Children decorating their bikes through their beliefs and culture.
- They make small and unique brandings showing their individuality
- So much care for the cycle when it is new.
- Once the bicycle gets decently old enough, they try different paint jobs on the bike.



6.2. Interaction with IIT campus school & Jr. college children

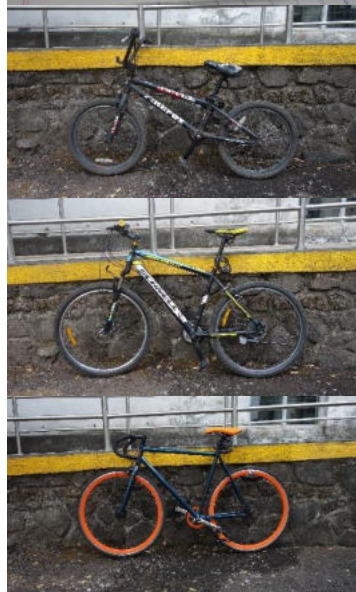
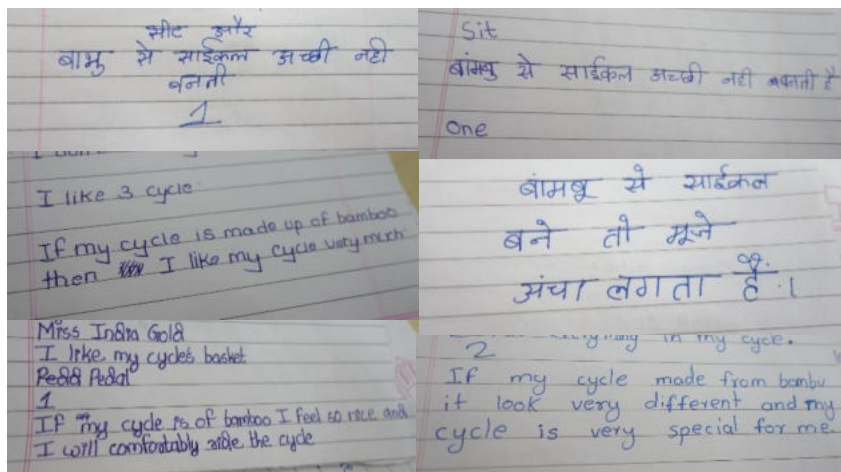
An interaction session was organized by the vice principal of the school, Mrs. Sridevi D.S as per my request to understand what a cycle was to a child. A total of 78 children were present for the session varying from 5th std - 8th std. The interaction was intended to understand the relation between a child and his cycle. This needed a small questionnaire to be prepared which had the following questions:

- i. NAME
- ii. AGE
- iii. WHICH BICYCLE DO YOU USE (if not possessing one, then name a model which you like in your neighborhood or experience)
- iv. WHAT DO YOU LIKE ABOUT YOUR CYCLE
- v. WHAT YOU DO NOT LIKE ABOUT YOUR CYCLE
- vi. WHAT IF BAMBOO WAS USED FOR YOUR CYCLE



Vote for the bike you want!

Along with the questionnaire a poll was held between 3 cycles having different characters speaking about itself. Children were asked to choose from the 3 cycles if they had to buy one.



22%
17/78

Firefox Skull

62%
49/78

Schnell Miracle

16%
12/78

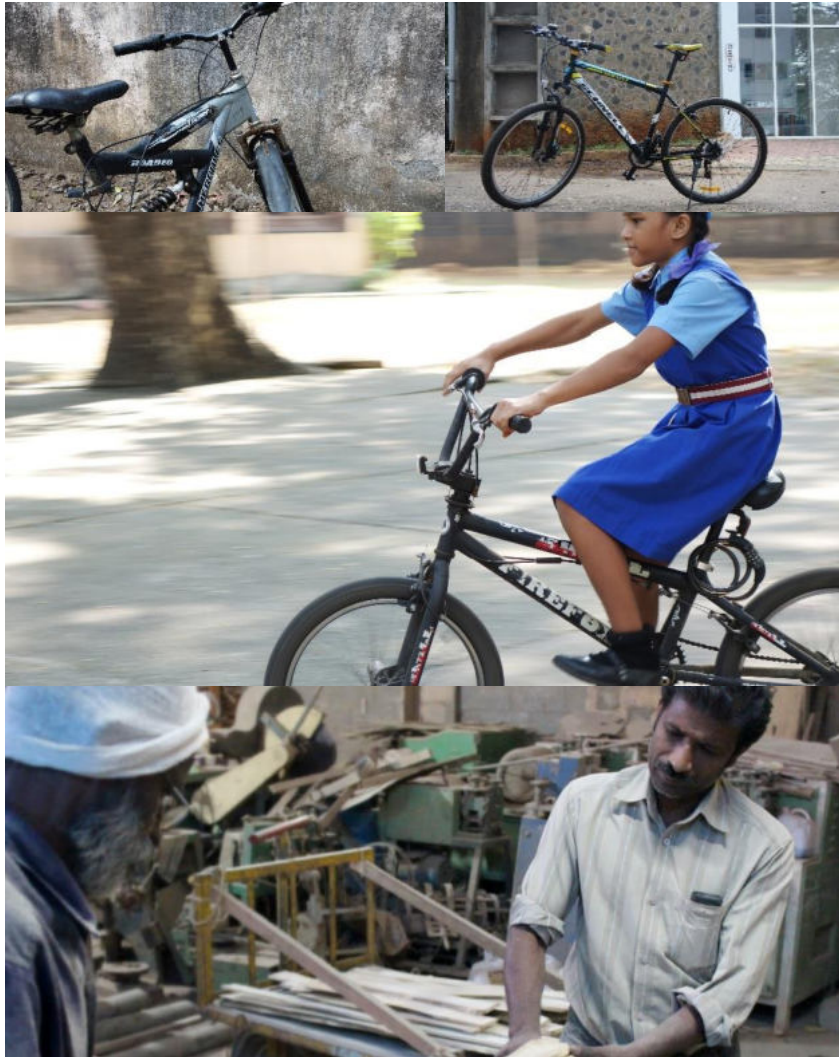
Firefox Flip-flop

Key observations

- A set of reactions to the question vi which is contrasting.
- Reaction to question v was majorly technical issues of the bike.
- Majorly used/liked bicycles among girls are Hero Miss India Gold and BSA Ladybird
- The 22% who likes the BMX was majorly dominated by the 5th and 6th std. (age group 10-12). Even riding the BMX had the same crowd.
- The vote for BMX had an even share between boys and girls.
- Schnell Miracle got the most major a attention with 62%
- The modern bicycle spares in the Schnell attracted the crowd. Color, graphics and the tires also played their share.
- A small section who likes the fluorescent tone of the Firefox flip flop. The 700 X 25C slim tires with the orange ring was the major concern for them in this cycle.

6.3. Inferences from the study

- Something NEW is acceptable in the specified age group
- The uncertainty about bamboo can be removed & making bamboo known to the children by possessing/working with the material.
- Visual aspects like color, graphics, components which a child would like on his/her bike
- Potential bicycle characteristics are known henceforth.
- The bicycle has a potential to be made by children themselves.
- Riding Posture is an important factor which should be considered while designing
- The essence of fellowship can be enhanced through the uniqueness of bamboo
- Bicycle is a possession for the children which they really care about.
- The uniformity in liking the BMX can be addressed through unisex bicycles.



7. Scenario generation

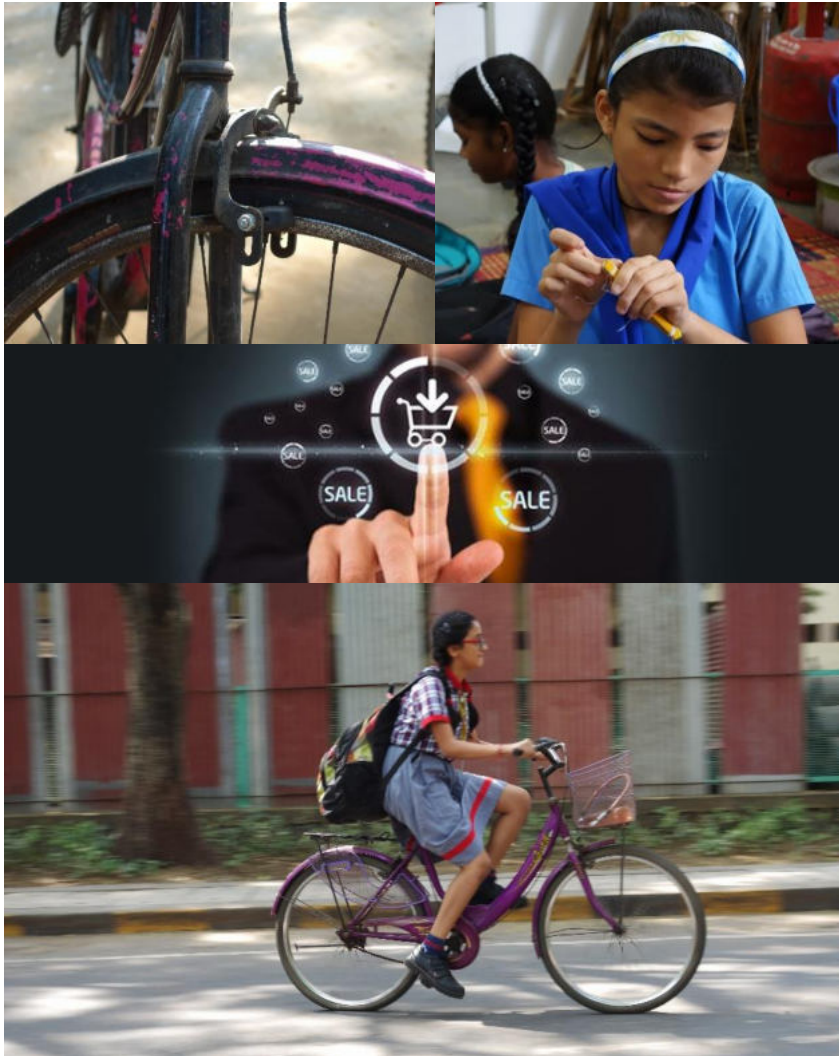
Based on the previous studies, four scenarios are generated. Each scenario addresses a certain set of inferences pertaining to certain needs of the bicycle. These inferences are mapped sequentially in each scenario.

Scenario I

The trend analysis showed the recent growth in the demand for foreign brands which shows that the Indian bicycle industry has to set new standards in bicycle design. A need to built elegant bicycles was prominent to address the growing ambitions of the people.

The user study later revealed that the bicycle design could incorporate unisex designs. This will address that 22% of children who liked that BMX bicycle kept for poll. The above mentioned statistic can be addressed by the craft sector of the country for its production and assembly.

The bicycle will also address the potential bicycle characteristics inferred from the used study which is the aspect of color, the bicycle attachments etc.



Scenario II

Children love to make small and unique customizations on their bike (inference from the user behavior study). Indian culture and traditions was rich in aspect of working with materials and making things. But due to various reasons there has been a decline in that culture and tradition.

The human world is surrounded with gadgets which are trying to make our living effortless. Amidst all those comforts, this design tries to revive that declining culture of working with things and making those unique and special specimens though the concept of DIY (Do It Yourself).

The rising E-commerce market can be made use here to address a larger portion of the bicycle demand as the time for assembly is saved and can be complimented in increasing the quantity of parts and packaging.

Scenario III

Children spent a major portion of their childhood in school with their teachers and friends. There can be reasons for them to like going to school or may not be also. But they have to go to school. But riding to school is also a herculean task as the ride is so constrained due to the baggage's and other reasons(from user behavioral study).



The bicycle has to address the riding posture in such constrained rides so that they are effortless to ride. The design can provide an upright posture to the rider thereby improving the riding comfort under load. The bicycle will also address the functional aspect of the existing bicycle attachments through bamboo if possible or as the way they are.

Scenario IV

A major portion of boys and girls to an extent are enthusiastic about speed. They love the joy of riding. It was observed that children fix races between themselves. To keep that sportsmanship running in them design intervention can be possible through the design of the bike.

As bamboo can express that need or desire through dynamic and flowing frame design using laminates or bent bamboo. Inspirations can be taken from the road bikes technology.

7.1. Inference from the scenario's

- Every scenario leads to a bicycle of its own kind specific to a purpose.
- Need to address the issues cannot be compromised.
- The concept DIY is a potential direction through which the needs in each scenario can be taken care of.

8. Design Brief

Design bicycle framework for children which will be a DIY kit. The frame design will take maximum leverage from the properties of bamboo. The frame will also use other natural/man made materials to improve the aesthetics of the bike or for the joineries between the bamboo sections.

Intent is to bring in expressions like Dynamism, Elegance, Robustness through bamboo sections and their joineries without much compromise in the strength of the structure.

Standard components

The frame will be able to accommodate the following standard bicycle components with their basic dimensions. The frame will also provide flexibility between standard sizes.

Frame size	flexible between 20 & 24 inch
Rim Brake sets	brake calipers with 10mm dia nut
BB axle	dia 22.mm
Wheel axle	dia 12mm
Tires and rims	dia 20 & 24

* as per availability in the market.

8.1. Target Users

Bicycles are the most affordable means of personal transportation for short distances. They most probably are the only means of personal transport for a child belonging to a middle/ lower class in the society.

The target users are children belonging to the age group 9-11 belonging to a middle class family. This age group shows children beginning to take their bicycles to schools & later on personal transportation becoming a basic need. The attempt to revive the culture of making things perfectly suits the age group as they get the exposure to Material and Science at a very young age.

The bicycle can also address the varied ambitions of the crowd through DIY.

8.2. Design considerations

Utilizing the craftsmanship

The components of DIY can be produced or made in various craft centers spread across the country. Since every bamboo has an individuality, it is difficult to exactly get the same copies in multiple numbers. The craftsmen knows the material and he can adapt to get the essential results.

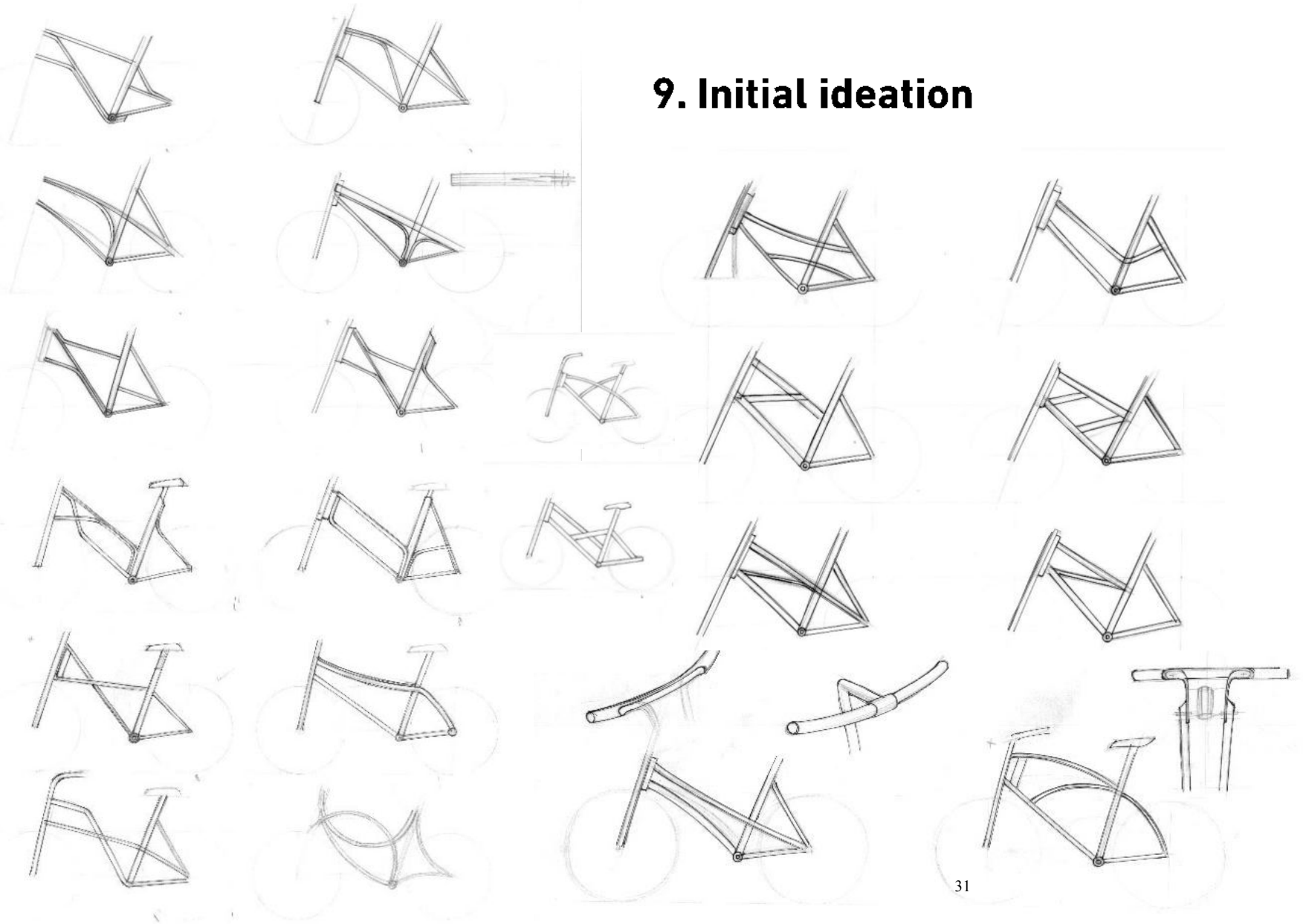
The Foreign competitor

Foreign brands are growing rapidly amongst the cycle owners in the country. They bring in the right sense of proportions and stance in the framework and brings in impressive graphics upon which the children fall in love. These aspects of stance, color and graphics will be blended in with the design.

Character of the bike

The bicycle will try to incorporate various ambitions on children like Speed, Strength, compassion, fellowship into the character of the frame through bamboo and the joineries

9. Initial ideation





Hollow Bamboo
Genera: Strictus/ Gigantus

Natural form of bamboo giving the best strength. But difficult to standardize.



Bamboo Splits
Genera: Strictus/ Gigantus
(span 30-40mm)

Provides flexibility and resistance to twist in one direction. Can be standardized.



Solid Bamboo
Genera: thyrostachys oliveri
40-60 mm dia

Offers better strength with the ability to bent with its natural profile. Heavier than the hollow bamboo.



Solid Bamboo
Genera: thyrostachys oliveri
20-30 mm dia

Offers flexibility to a great extend.



Bamboo ply
Genera: Strictus/ Gigantus

Splits are applied with adhesives and pressed. Provides strength and flexibility and can be standardized.



Bamboo splits
Genera: Strictus/ Gigantus
Span 30-40mm

Thick splits applied with adhesive and pressed. Different cross sections possible with this type.



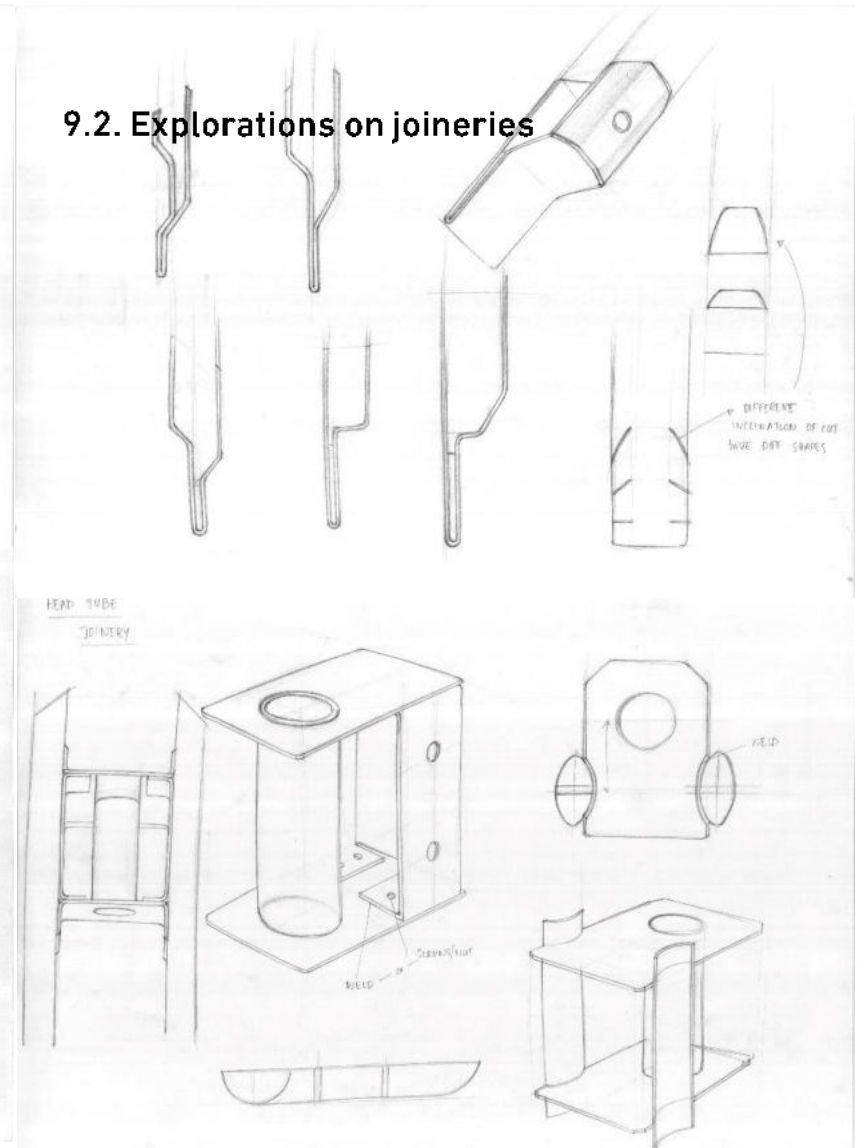
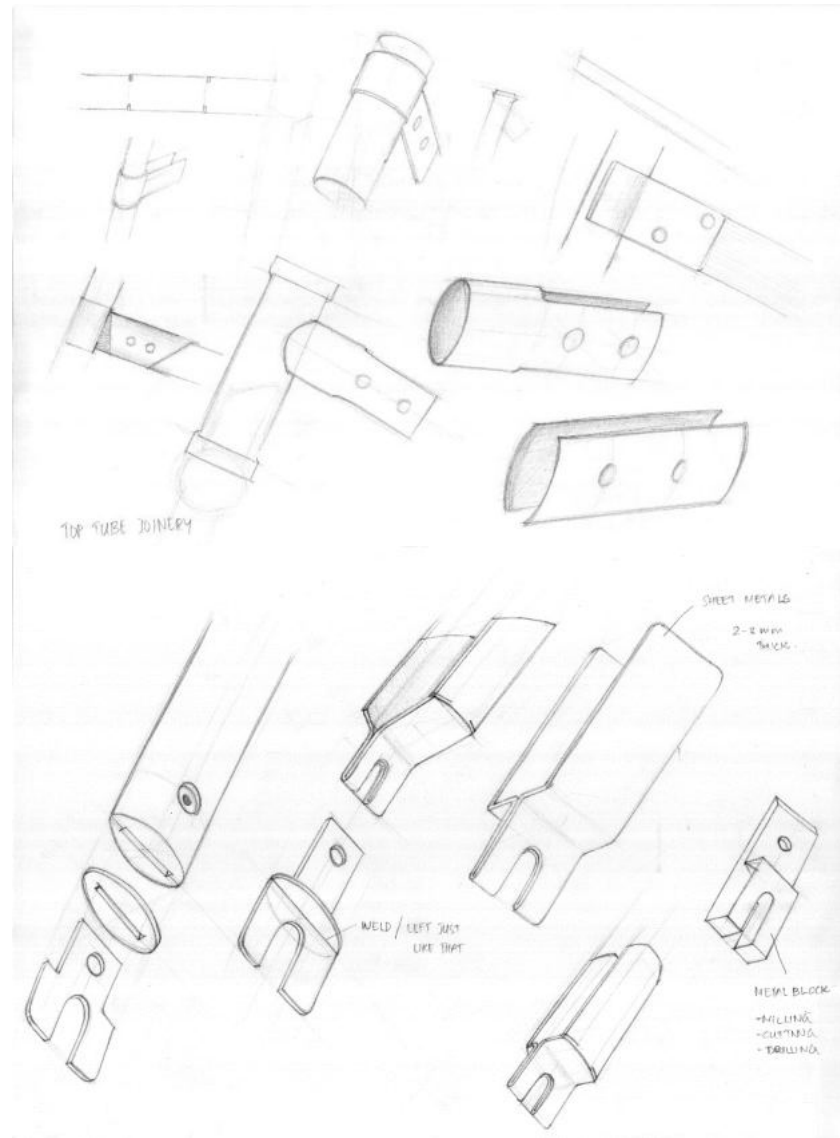
Bamboo splits triangular sections
Genera: Strictus/ Gigantus

Visually different from the natural form but provides the strength. Can be used only for linear lengths.



Bamboo splits hexagonal
Genera: Strictus/ Gigantus

Strong and can be standardized.



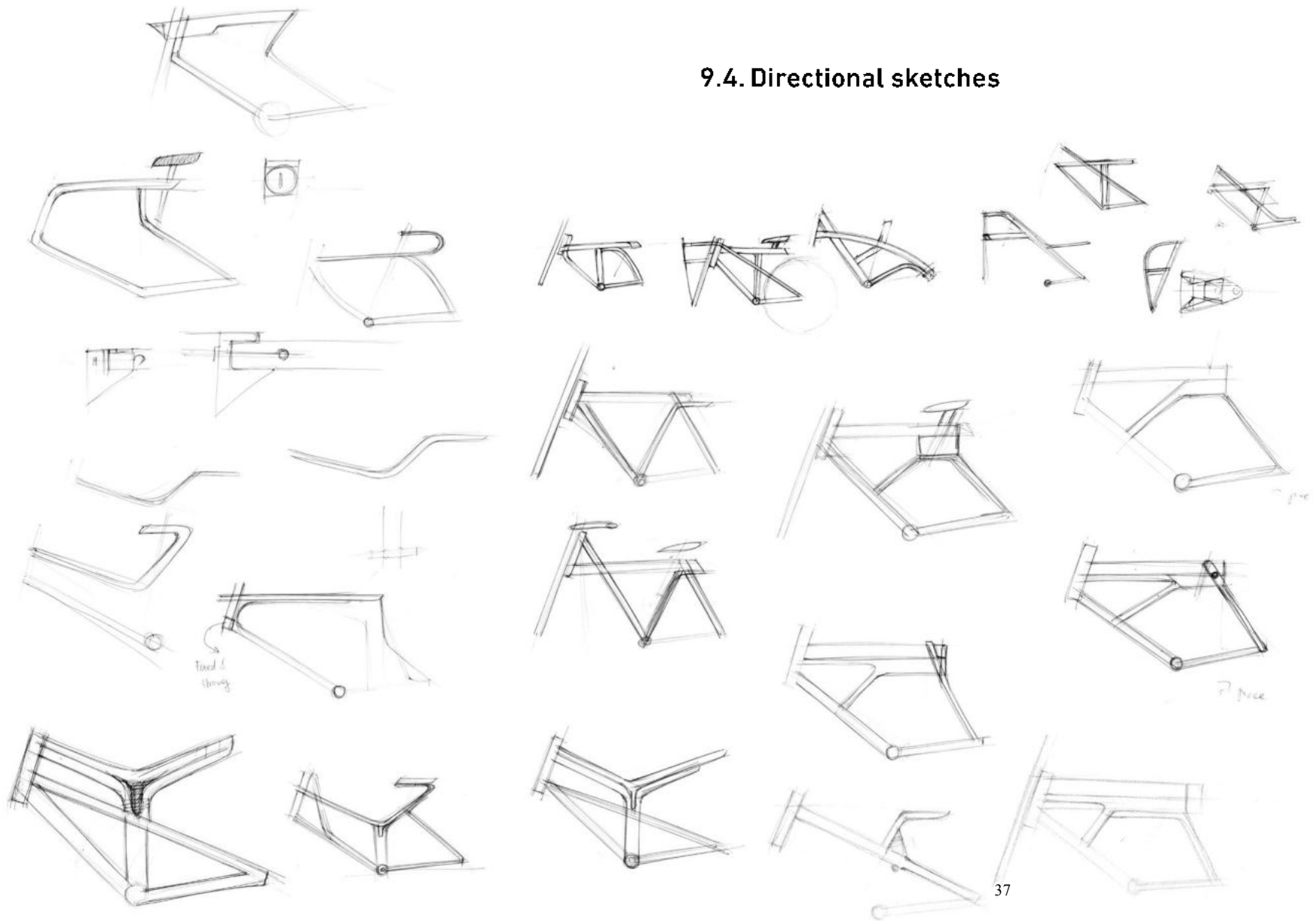


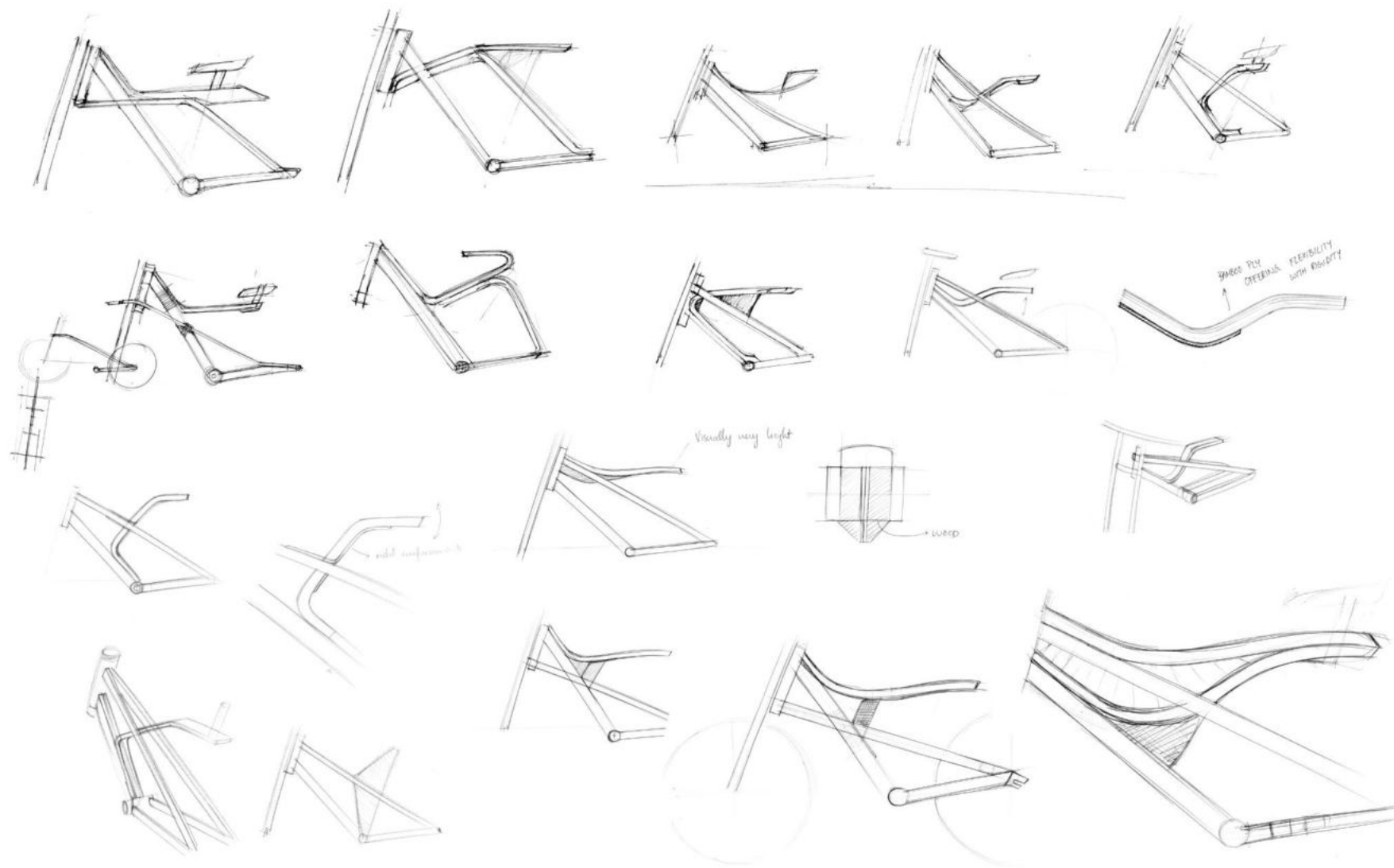
explorations on sections and joineries.

9.3. Initial Mockups



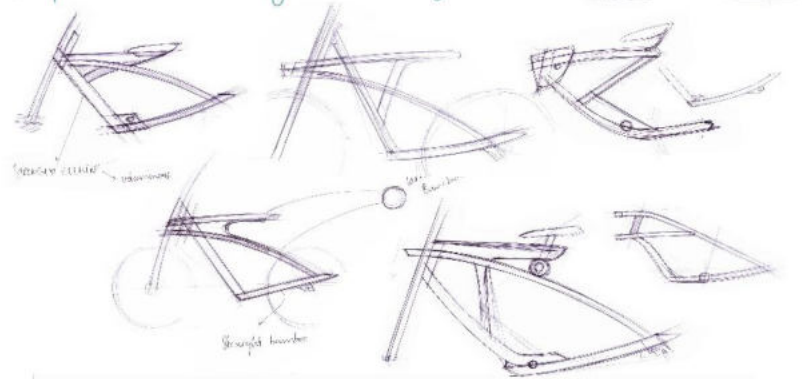
9.4. Directional sketches



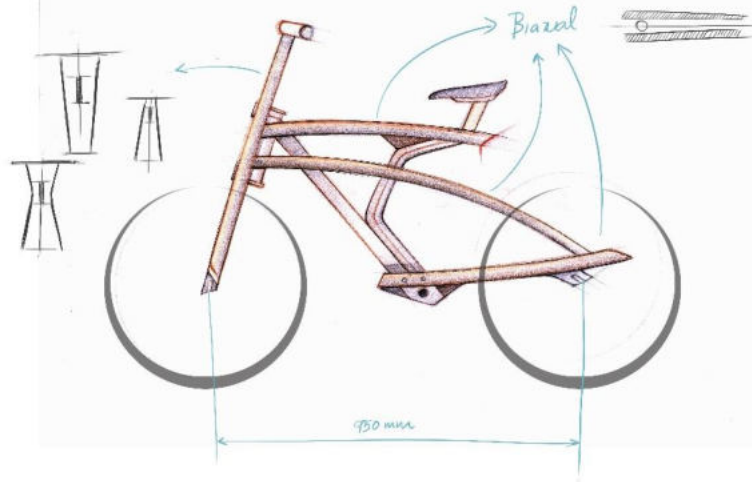


CONCEPT 1

Properties: Elasticity/Flexibility



no of bamboo components: 11

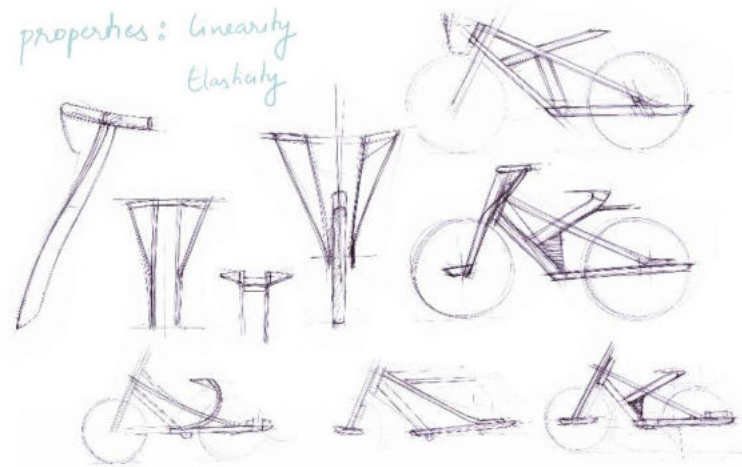


9.5. Concept generation

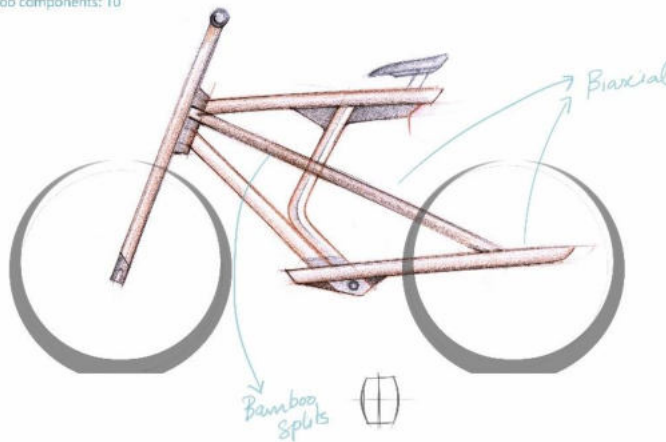
Concept 1

- Taking the leverage from the elastic properties of Bamboo.
- Biaxial bamboo top tube and chain stays.
- Solid bamboo and bamboo splits being used.
- Solid bamboo making subtle top tube curves.
- Total no: of components = 11

CONCEPT 2



no of bamboo components: 10

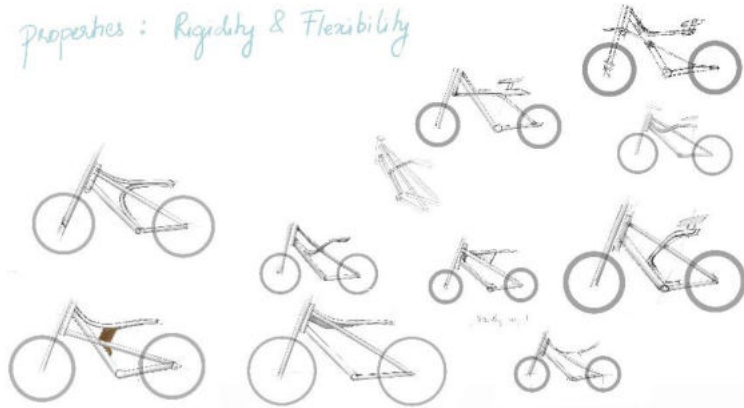


Concept 2

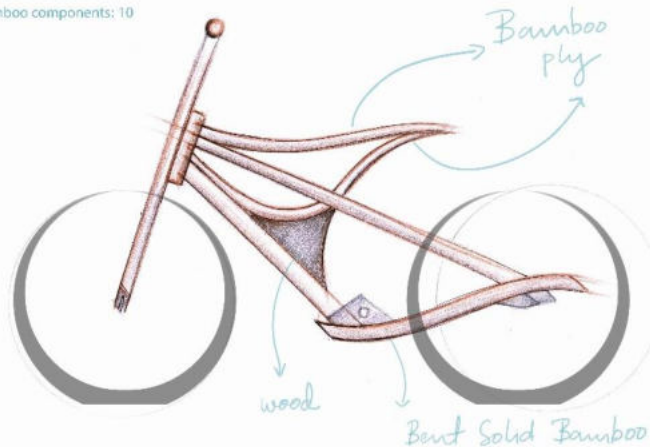
- Taking the leverage from the linearity and stiffness of bamboo
- Extended chain stays providing natural suspension.
- Solid bamboo and bamboo splits being used.
- Natural profile for strength and rigidity
- Total no: of components = 10

CONCEPT 3

properties: Rigidity & Flexibility



no of bamboo components: 10

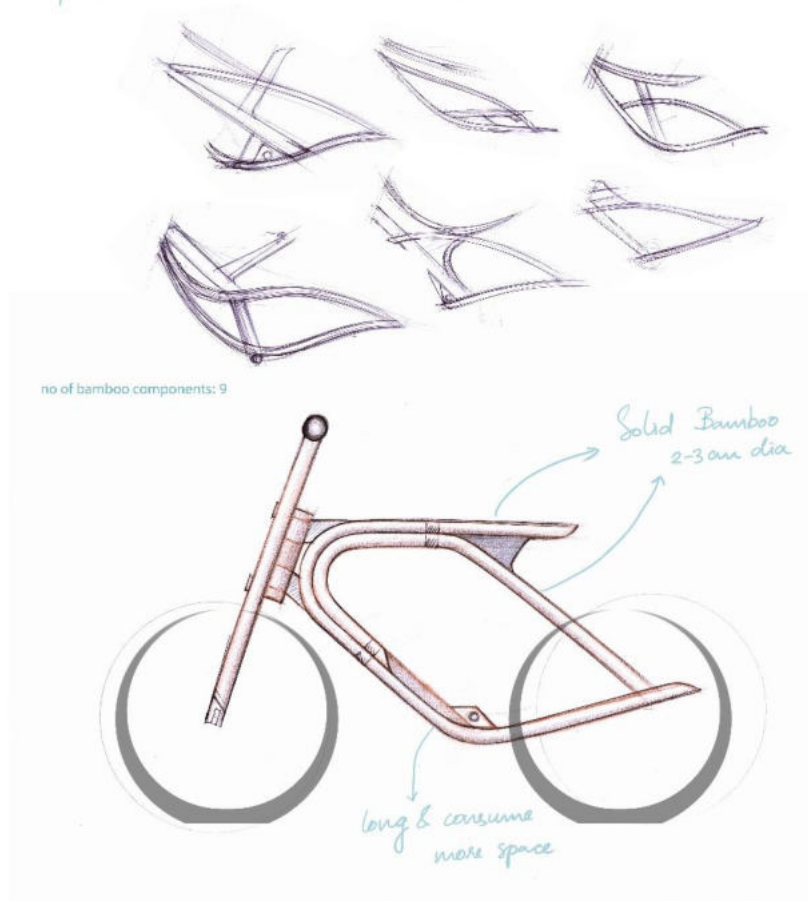


Concept 3

- Taking the leverage from the elastic properties of bamboo
- Biaxial seat stays and chain stays.
- Bamboo splits being used.
- Dynamic top tubes
- Total no: of components = 10

CONCEPT 4

properties: Natural profile of Bamboo



Concept 4

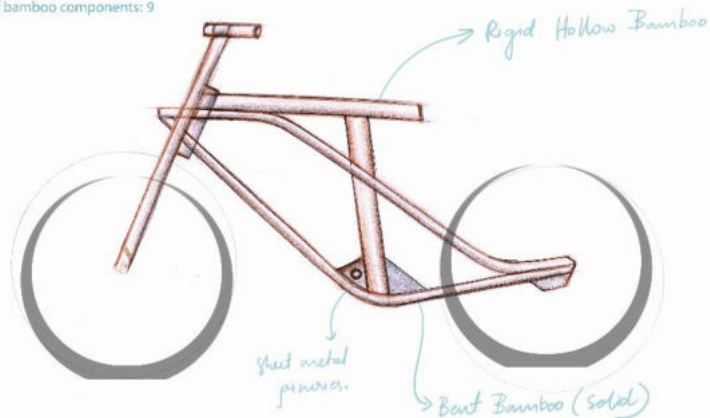
- Taking the leverage from the elastic properties of bamboo
- Biaxial top tube and chain stays.
- Solid bamboo bent to obtain a closed loop structure.
- Solid bamboo bending is a major operation.
- Total no: of components = 9

CONCEPT 5

properties: Rigidity of Hollow/ Split Bamboos.



no of bamboo components: 9



Concept 5

- Taking the leverage from the elastic and rigid properties of bamboo
- Biaxial bottom tube and chain stays.
- Botto tube and chain stay combined into a single part.
- Seat post and top tube with natural bamboo profile.
- Total no: of components = 9

Concept evaluation

Concept 4 being taken forward for mockups and final prototyping due to

- Simplicity and aesthetics of the framework
- Elastic leverage of bamboo
- Lesser no: of components

But the design slightly compromises the packaging volume.

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9.6. Mockup model 1



9.7. Mockup model 2 (Final)

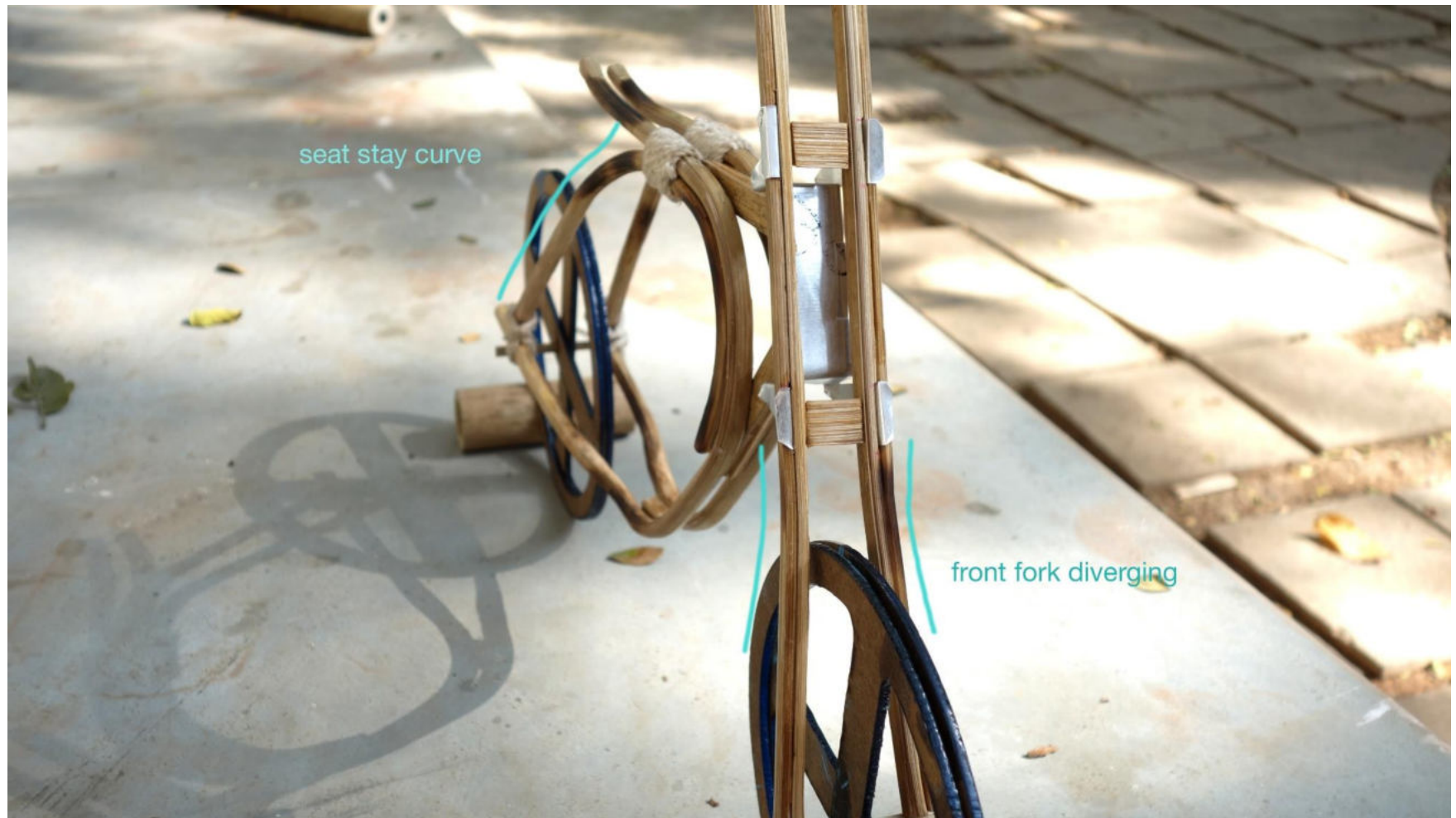








flow of line and
seat housing



9.8. Exploded view



10. Prototype 1





