Greencycle

A Human Centred Design Approach for the Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries

VOLUME 1

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Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the qualification of any other degree or diploma of a university or other institution of higher learning, except where due acknowledgement is made in the acknowledgements."

Paulus Maringka, July 2010

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Abstract

This Greencycle project applies a system approach to shift design thinking and practices away from the ongoing unsustainable use of resources towards a more sustainable framework of consumption whereby local cultures, skills, resources and technology are analyzed to inform the design and development of a human powered transportation system.

It uses a trans-disciplinary research and design approach by consulting all stakeholders; including farmers in a Third World country, industrial designers, engineers and manufacturers to provide information, understanding and insights as a basis to find solutions that have enabled this research study to produce a system called Greencycle which utilizes renewable materials and indigenous people skills to produce a bicycle that is more sustainable.

The bicycle provides more than basic transportation to go from A to B. Poor countries need and depend on this mode of transportation for a wide range of uses; thus expanding its function and uses would be of great benefit to its users. This research study has created a series of accessories to extend a bicycle's functionality, with the core being made from sustainable materials and local skills.

Fig 00. A cyclist in the morning

For this project it would have been a simple process for the designer to come up with a concept idea(s) that was based on a personal view of what would be a suitable solution for the target user. Instead however, the designer has used feedback from the target group participants to shape and develop the design process and to ensure the design will be acceptable for the target user to use and manufacture.

This research study has included four expert interviews, eleven case studies of target users, prototype testing and field experiments with sustainable resources to gather information, understanding and insights from these stakeholders in order to propose, design and evaluate two Greencycles (using sustainable bamboo material) and a series of design accessories. This multi-discipline approach to the design problem has revealed many opportunities that would otherwise be hidden by less detailed research and design methodology.

Many academic studies stop at the point when the written thesis is complete. This research project went a step further by testing and implementing its findings on users back in its intended marketplace to ensure the design will be adopted by and be successful for people in Third World countries. As a result of this research, there is now an opportunity to look at and create a business model that provides new income opportunities for the local people.

Feedback for the Greencycle design and its accessories has so far been very encouraging, with participants showing a significant level of enthusiasm. To take advantage of this success, a business proposition to market these sustainable products seems plausible as a first step to developing this business venture. Information posters to showcase the accessories and their functions and applications have been designed to test market demands and other important indicators for future business development and strategy.

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Volume 2 - Appendices

1.1 Introduction

The main aim of this Master of Philosophy research study is to apply a human centred design approach to the analysis, design and evaluation of the humble bicycle. The objective is to extend and adapt its function and use for people in developing and Third World countries such as parts of China, India and Africa.

The research applies design thinking and innovation to improve on this form of human powered transportation, taking into account functionality, the needs and wants of the users and the use of appropriate technologies and environmental considerations. The focus of human centred design is to improve the usability of a product or service so that it becomes more personally related and meaningful to the user's life.

Trans-disciplinary research and design approaches are used to ensure that researchers, practitioners and stakeholders co-operate to explore complex human-machine-environmental issues. (Nicolescu, 2007), (Peterson, et al., 2000) These issues include exploring new cleaner/greener materials and processes, social issues in relation to economics and new business, and labour models to ensure the sustainability of this project. Considerations are also given to other human factors that are equally important, but often difficult to resolve because of old habits, inheritance or an unwillingness to make new changes.

Information gathered from observation and interviews (target users and bicycle manufacturers) in Indonesia has provided a good understanding of bicycle use in relation to the user's needs and wants in their natural environment. This information has also provided insights on how low income users modify their bicycles to maximize their use and accommodate their needs. This information has been used to produce and analyze a series of new concepts for bicycles and bicycle attachments to increase the bicycle's load capability. A series of scale models were constructed to explore different types of load and weight options as well as customization to suit the different needs of users.

These models were also presented to various expert interviews for critique and feedback on each idea and the working mechanics of each design. Findings from these interviews were used to inform, improve and validate the scale models. Expert interviews and a field experiment on bamboo were also conducted to explore the use of manipulated and processed bamboo as the main component of the proposed designs.
The centre of research was Indonesia. This was necessary not only to validate the design idea, but also to understand

the logistics of the design implementation and any problems arising from that in a Third World country. Two Full-size Trailer prototypes were built, tested, evaluated and distributed to target Indonesian users. This field test was to see if the target users were willing to accept and try new ideas, and to evaluate whether the criteria have been met from previous findings as well as find out what the user would do to this prototype to adapt it to suit their daily activities.

Knowledge and insights gathered from this field experiment were used for the final proposed design development of the full-size Greencycle prototype. A series of commercially viable and environmentally sustainable components to enhance the usability, functionality, desirability and sustainability of the humble bicycle is also proposed as a business venture to market them along with the Greencycle.

1.2 Problems and Opportunities

Since the 1950s, in parts of Third World countries like China and India the bicycle has become the dominant form of transportation, where it is seen as a status symbol and something to aspire towards having. Today, bicycles are still the most ideal form of transportation, providing a convenient, economical and ecologically friendly way to get around.

Fig 01. A cyclist with his child trying to cross the road at a busy intersection in Beijing

Recently, on-road bicycle numbers have been eclipsed by the car. China, with a population of 1.3 billion, is predicted to have 140 million cars plying its roads by the year 2020. The Deputy Director of the Communication Ministry’s Comprehensive Planning Department, Li Xinghua, predicted that the number of cars in China will eventually reach 250 million or about 150 cars for every 1000 people. (Business Report, 2004) The same report also predicted that by 2050 India, with a population of 1.1 billion, will have 382 cars per 1000 people, compared with China’s 363 in that same year. (Business Report, 2004)

With the depletion of raw materials and oil in many parts of the world, these staggering numbers are unsustainable. The American Petroleum Institute in 1999 predicted that the world's oil supply would be depleted between 2062 and 2094 with the increased rate of current oil consumption. (FYI, 1999)

These scenarios signal that there is an urgent need for more sustainable forms of transportation, not only to reduce carbon emissions but also to produce more practical and affordable solutions with consideration to environmental and material sustainability. The basic form of the bicycle has not changed much in the last 50 years. In light of all this, the existing design of this human powered form of transport is no longer efficient enough to fulfil the needs of its users, whose livelihoods depend heavily upon it. This opens up a new opportunity to explore, design and develop an Immediate Means of Human Powered Transportation that meets current and future requirements of functionality, usability, affordability, sustainability and desirability.

With the combined population of China and India alone being 2.4 billion, this research project could provide an opportunity to bring about real human powered transportation solutions for low income users all over the world.

1.3 Structure of Thesis

This thesis consists of seven chapters:

Chapter 1: Introduces and scopes the areas of research and need for functional, usable and sustainable human powered machines.

Chapter 2: Provides critical analysis through literature review and internet ethnography to gain an understanding and knowledge of bicycle functionality and bicycle users in Third World countries. This chapter also reviews literature and provides a study background on Bicycle Ergonomics, Green Materials and Sustainability.

Chapter 3: Outlines the research design and design methods approach to the design generation and development of the Greencycle and accessories.

Chapter 4: Presents the significant findings and the major discoveries that formed the design criteria of the Greencycle and accessories.

Chapter 5: Details the design phases and iterative processes in the development phases of the Greencycle and the accessories.

Chapter 6: Details the evaluation outcomes of an integrated approach for the concept design thinking of the Greencycle and accessories, including materials and manufacturing processes.

Chapter 7: The Discussion and Conclusion provides a reflection on what has been achieved and the future of the Greencycle and the accessories.

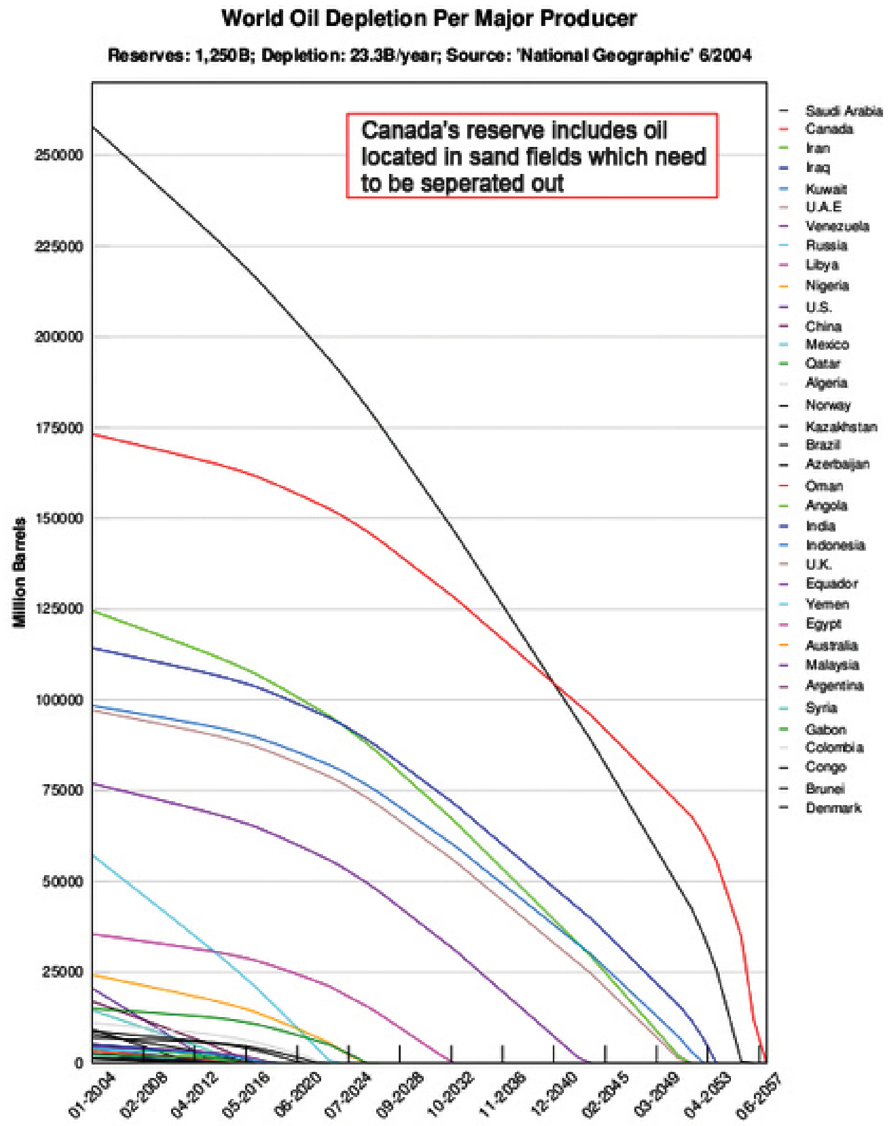


Fig 02. Diagram of world oil depletion

2.1 Transportation in Third World Countries

In the 21st century, our daily lives are fast moving. This fast pace even applies to Third World countries and to those people who are in the lower income bracket. Globally in the transportation field, it appears (on the surface at least) that high technology and rapid people-moving systems are being increasingly employed as demand rises. (Stough, 2003) However, the various modes of transport available in parts of Third World countries like Indonesia, India and China remain more traditional, slower and much less high-tech.

In these countries, the most common way to get from point A to B, particularly in rural areas, is on foot. In rural communities, very few people have enough money or have the luxury of owning a motorcycle. The motorcycle, with all its best intentions, is not always suitable for the rural environment and terrain, e.g. a padi (rice) field. The main issues hindering motorcycle ownership are the lack of fuel available in remote areas, the cost of licensing, government regulation and ongoing maintenance. All of these make the motorcycle a less desirable form of transportation in poorer communities.

Fig 03. Farmer carrying load on his back

Fig 04. Women on foot carrying water in Africa

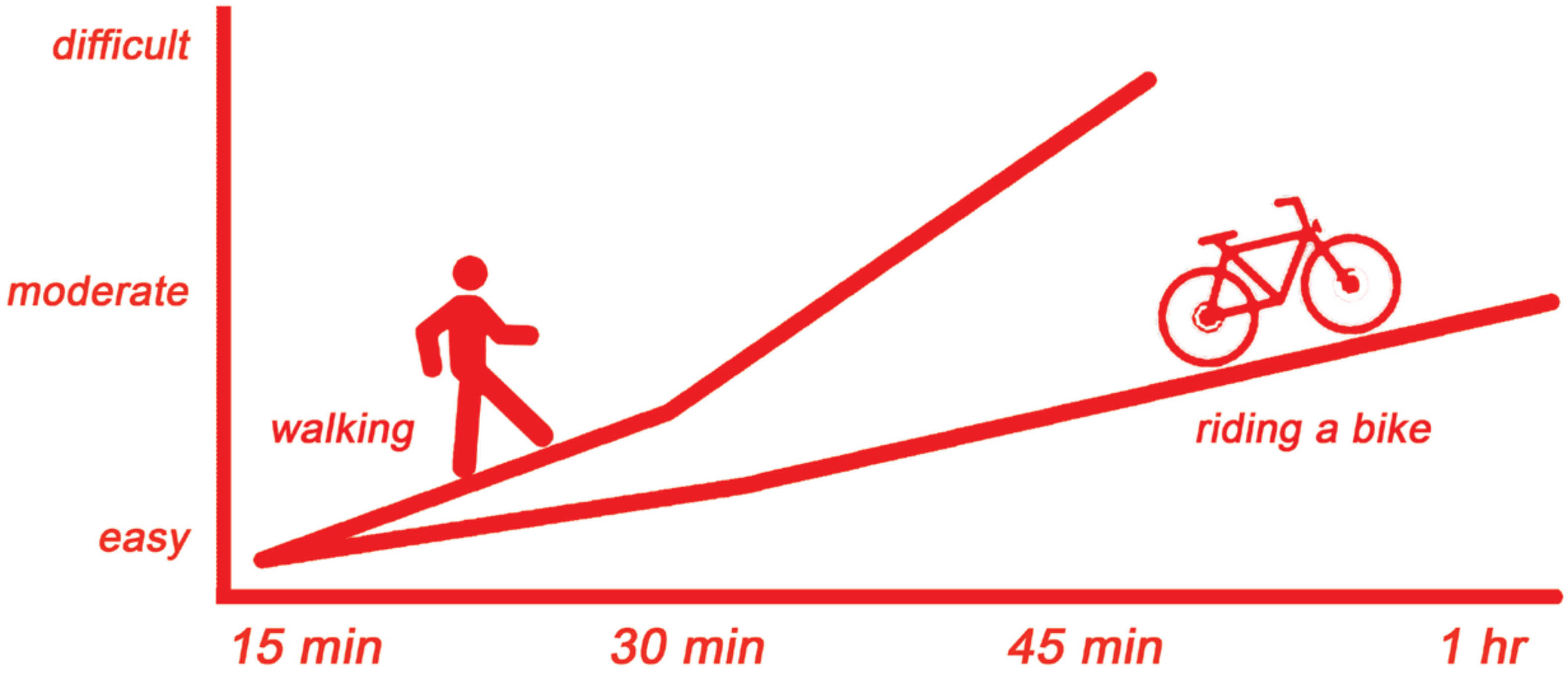


Fig 05. Diagram comparison between walking and riding a bicycle

Walking, although free, is not very practical for a long distance journey, carrying a heavy load or an urgent arrival. Currently, bicycles and push-carts are still widely used in less developed countries as a major part of daily life. They are used to carry farm produce to market, take children to school, and occasionally act as a carriage to take a loved one for a romantic ride under the moonlight. They not only transport goods, but for many users they have become an integral part of their livelihood and earning capacity.
In the rural areas of China, many girls ask their boyfriends to guarantee them the three things that go round: a watch, a bicycle and a sewing machine, before agreeing to marry them. (Starrs, 1982)

Riding a bicycle is on average three times faster than walking and significantly less costly than a motorcycle.

The bicycle has played an essential role in transportation in most of these Third World countries. Although it was invented in Europe for a Western market, the bicycle no longer belongs to Europe alone. As a mode of transport, bicycles and tricycles are much more common outside of Europe. In Asia, bicycles transport more people than all of the world's automobiles. (Schinnerer, 1997)

In India, the bicycle industry began in the 1930s, with the assembling of imported parts from the Raleigh Company in England. A year later, they were making frames locally and building complete bicycles shortly after that. By 1987, India was producing five and a half million bicycles and exporting their bicycles in large numbers. The Indian bicycle manufacturing industry has also been instrumental in establishing production facilities in other Asian countries. (Dodge, 1996)

Fig 06. A common road scene in China

Even in Bangladesh, the government's disregard for the rickshaw was clearly articulated in its third Five Year Plan of 1985-90, which stated that, "slow moving vehicles such as pedal rickshaws, push and pull carts...should be gradually eliminated through development of automotive vehicles and training of existing operators for such vehicles." (Gallagher, 1992)

Fig 07. A rickshaw in India

Fig 08. A becak in Indonesia

In 1980 in Djakarta, Indonesia, fifty thousand becaks were thrown into the sea in an attempt to rid the city of tricycles. The Indonesian government believes that Indonesia will never be able to be in the same position as other modern countries while Jakarta still has becaks on its streets. (Kiefer & Jellinek, 2001)

In large cities in China, bicycles are beginning to be banned from certain streets where they are held responsible for congestion, despite the fact that they often travel faster than the motorized traffic. This negative attitude towards the bicycle has been encouraged by the World Bank which provides transport funds to developing countries. Even their comprehensive four hundred page report on transportation in China failed to use the word “bicycle”. (Cecchini & Prennushi, 2002)

Recently, on-road bicycle numbers have been eclipsed by the car. China, with a population of 1.3 billion, is predicted to have 140 million cars plying its roads by the year 2020. The Deputy Director of the Communication Ministry’s Comprehensive Planning Department, Li Xinghua, predicted that the number of cars in China will eventually reach 250 million or about 150 cars for every 1000 people. (Business Report, 2004)

It is also predicted that by 2050, India with a population

Fig 09. A rickshaw in China

of 1.1 billion, will have 382 cars per thousand people compared with China’s 363 in that same year. (Business Report, 2004)

It is predicted that the world’s oil supply will be depleted between 2062 and 2094 with the current rate consumption (FYI, 1999) and this demonstrates there is an urgent need for more sustainable forms of transportation not only to reduce carbon emissions but also to produce more practical and affordable solutions with consideration to the environment and material resources.

In addition to all this, the existing design of human powered forms of transport is no longer efficient enough to fulfil the needs of its users, whose livelihoods depend heavily upon it. This opens up a new opportunity to explore, design and develop ways of increasing the value of human powered transportation that meet the current and future requirements of functionality, usability, affordability, sustainability and desirability. Increasing the functionality of bicycles for the lower income bracket will also mean improving accessibility to markets, schools and basic social services which are key to fighting rural poverty. (Asian Development Bank, 2005)

2.2 Bicycle Power

Although there was great interest for the bicycle in most 'Western developed' countries in the 1890s, this had fallen sharply by the end of the decade. In Britain, petrol (gas) was first rationed for private use during World War II and the bicycle was used widely. When motor fuel and cars became available and affordable again after World War II ended, the bicycle in many Western countries was reduced to being used by children. By comparison, in the Third World, the bicycle was and still is a necessity for everyone who is in the lower income bracket. In most of these countries, especially China, the proportion of person-trips and freight moved by bicycle is possibly still far greater than taken by railroad traffic. (Wilson, 2004)

During one day a person can commute up to 16km. Cycling is four times faster than walking. A bicycle saves three hours walking time thus there is three hours more each day to generate an income. The effort to travel increases as time increases. Riding a bicycle requires less effort, allowing one to travel further in less time.

Riding a bicycle increases one's capacity by five times. Over equal units of time, one can ride a bicycle four times the distance as one walking. Many different factors combine to influence levels of transport utility. In developing countries, many utilize cycling simply because the bicycle is the most affordable form of transportation available to the lower income bracket. In developed countries, where people have the choice of many different types of transport, a complex interplay of other factors influence the level of bicycle use.

To have a humble bicycle in the lower income bracket means improving accessibility to the markets, school and basic social services which are key to fighting rural poverty. Sustainable mobility is a very basic foundation

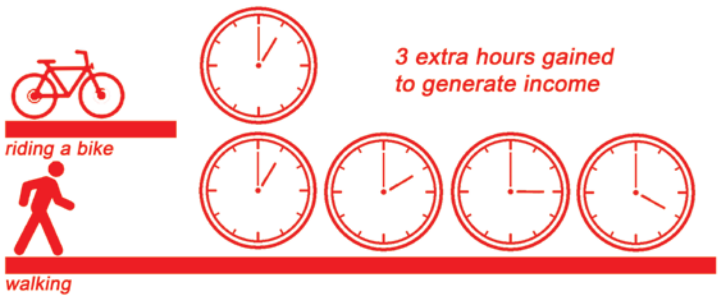


Fig 10. Diagram comparison between walking and bicycle riding (time saving)

Fig 11. Diagram comparison between walking and bicycle riding (distance)

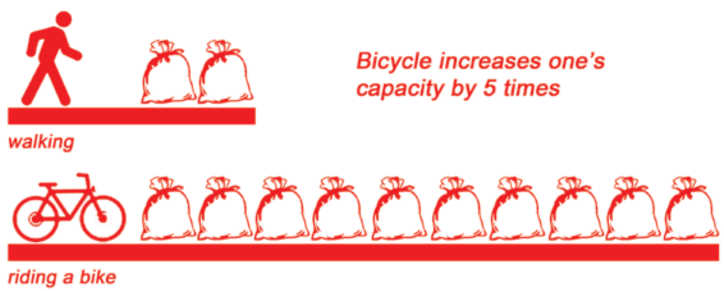


Fig 12. Diagram comparison between walking and bicycle riding (loading) (Source: Cycling out of poverty.com)

for all economic systems. (Goldman & Gorham, 2006) Bicycles have not only enabled them to bring goods and services to market but also to put distant schools and health care within reach. They encourage an individual's entrepreneurial drive to be independent and an entire business can be run off the back of a bike.

In parts of Africa, in some of the refugee camps where there is no available or appropriate means of transport, people have to walk about 12km to get to the nearest health centre clinic and up to 50km to the nearest district hospital. (First African Bicycle Information Organization, 2010) By having a simple form of human powered transportation such as a bicycle available, this would not only reduce the cost in time, energy and money but also give people access to health care and other services.

In developing countries, the bicycle plays an important part in a decentralized government health program, making the delivery of vaccines and medical care possible to some of the inaccessible villages. (McGurn, 1987)

Many people who cannot afford a bicycle have to spend a large part of their income on transportation, for example a trip to market for buying or selling produce, a trip to the clinic, or the daily trips to school. Investing in a bicycle however does pay off, since their daily expenses are reduced and by owning one it is possible to engage in other income generating activities.

In Africa women do most of the daily chores: work in the field, collect firewood and take care of the children, etc. Research has shown that men and children in households that own a bicycle do more household tasks because a bicycle is seen as a status symbol and they like being seen on it. What's more, children enjoy cycling. (Benefits of bicycle, n.d.)

2.2.1 UN Millennium Summit September 2000

In September 2005, the UN hosted a Millennium+5 Summit to evaluate the progress towards the goals spelt out in the document. There were eight goals set up to be achieved by 2015 that respond to the world's main development challenges drawn from the actions and targets contained in the Millennium Declaration, which was adopted by 189 nations and signed by 147 heads of state and governments. (Global Policy Forum, 2005)

These goals, known as Millennium Development Goals (MDGs) are:

- Eradicate extreme poverty and hunger.
- Achieve universal primary education.
- Promote gender equality and empower women.
- Reduce child mortality.
- Improve maternal health.
- Combat HIV/AIDS, malaria and other diseases.
- Ensure environmental sustainability.
- Develop a Global Partnership for Development.

Many believe, the bicycle contributes to the MDGs as formulated by the UN and can break the vicious circle of poverty by:

- Creating opportunities to increase income and new opportunities in the job market.
- Giving better access to schools and heath centres.
- Enabling teaching and medical staff to cover large areas more quickly.
- Giving a more equal position for women and men in the household.

Fig 14. Donated bicycles ready to be shipped

2.3 Bicycle Movement

Not only is the bicycle the most ideal form of transportation for most developing countries, it is also an economical and more ecologically friendly way to get around. The bicycle has become a dominant form of transportation, and in China it has been seen as a status symbol and something to aspire towards having since the 1950s. (Bicycle of China, 2008)

Fig 13. Shanghai bicycle propaganda poster from 1902, when the bicycle was still an expensive novelty item.

The Institute for Transportation and Development Policy (ITDP), founded in New York in 1985, was the advocate partly responsible for changing the view and policy of the World Bank and helped to co-ordinate a recycling project by collecting donations of used bikes from the United States and sending them to Third World countries. (ITDP, 1985)

Many non-profit organizations around the world are using bicycles as the main ammunition to fight against world poverty in Third World countries. Organizations like “BfW” (Bikes for the World) have donated and shipped over 40,000 bikes to developing and Third World countries around the world. Their mission is to start by collecting valuable but unwanted bicycles and related material parts, tools and accessories in the United States and deliver them at low cost to community development programs assisting the poor in developing countries. Following this initial stage, they help to set up self-sustaining bicycle repair operations which can make enough money to pay the direct costs for subsequent container shipments of donated bicycles. (Bikes for the World, 2010)

Fabio (First African Bicycle Information Organization) is a Ugandan based non-governmental organization that believes in utilizing non-motorized transport as a vital tool for sustainable development. One of the contributing factors to poverty in underdeveloped countries is the lack of viable forms of transportation. Fabio believes it is necessary to stay conscious of the global environment to insure the sustainability of economic and social growth by improving public transportation systems and the legal rights of bicycle users on roadways. (First African Bicycle Information Organization, 2010)

Fig 15. A bicycle in Uganda

BAP (Bicycle against Poverty) is a student led, non-profit organization founded at Bucknell University. Although the BAP organization operating model seems businesslike, all profits go back to the community. Their mission is to encourage community co-operation, to improve accessibility to important resources and use the bicycle as a tool for economic development for low income families in Third World countries. (BAP, 2009)

Two of the first cargo bikes have now become a permanent display in the Smithsonian National Design Museum. “Design for the other 90%” was a thesis project started about a decade ago that has become one of many projects exploring the use of the bicycle in the attempt to increase incomes and reduce poverty throughout Latin America and Africa. The first prototype was conceived in Nicaragua and originally prototyped as a transport solution for local farmers. The original bicycle has been modified and given a longer tail frame to serve as a cargo bike. Since then the cargo bike frame has been manufactured overseas and assembled locally. It is a successful program which relies on volunteers and donations.
(Worldbike, 2010)

Fig 16. A cargo bike

2.4 Bicycle History

“The inventions that change the world are often those that carry the most sublime versatility, a seamless transfer from one to the next. The bicycle is one such invention.” (Strickland, 2003)

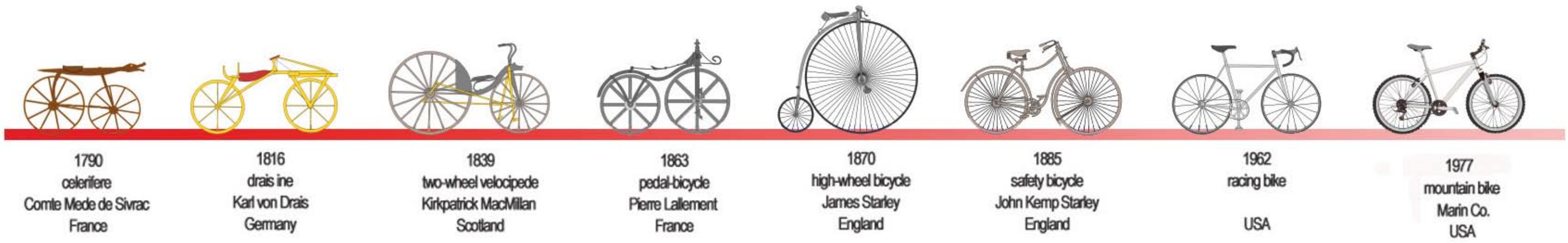


Fig 17. Diagram showing the history of the bicycle

2.4.1 Da Vinci

The history of the bicycle is not definitive and literature sources often disagree as to the names of the inventors and the dates of their inventions. Leonardo Da Vinci sketched a true copy of the modern bicycle in 1490. It was way ahead of its time and as far as history records show it never left the drawing board. (Davenport, 1997)

"Learning to ride the velocipede was no easy task, even at the rink, as one journalist from Malden, Massachusetts, discovered." (From the Malden Messenger, 13 February 1869)

2.4.2 Celerifere

Around 1791, a French craftsman named Comte Mede de Sivrac developed a "Celerifere" running machine, which had two in-line wheels connected by a beam. The rider sat above this beam and pushed forward with foot movements on the ground keeping the vehicle moving.

The celerifere is the first contraption that can realistically be said to resemble a bicycle. In another words, it was one of the earliest bike prototypes but had no pedals or steering. (Hoare, 1984)

2.4.3 Hobby Horse

A steering mechanism attached to the front wheel on an improved celerifere-like model was created in 1817 by German Baron Karl von Drais de Sauerbrun. It was called a "Draisienne", after the inventor himself and also called a "hobby horse". (California Bicycle Museum, 2009)

2.4.4 Kirkpatrick MacMillan

Bicycling suddenly took a giant leap forward in 1839 when a Scottish blacksmith named Kirkpatrick MacMillan used his skills and tools to attach treadle-type pedals to a bicycle that could more effectively drive a bike forward. These pedals were attached to the bicycle's wooden frame and iron-rimmed wooden wheels using connecting rods. Unfortunately Macmillan saw little profit from his innovation. (Stevenson, 2008)

2.4.5 Velocipede

The Boneshaker or Velocipede ("fast foot") was invented in 1863 in France by Pierre Lallement. It was made of stiff materials, straight angles and steel wheels, which made this bike literally a bone shaker to ride over the cobblestone roads of the day. The improvement was a front wheel with direct drive peddles, a fixed gear and one

Fig 18. Model of “Da Vinci” Bicycle

Fig 19. Celerifere

Fig 20. Hobby Horse

Fig 21. MacMillan invention

Fig 22. Boneshaker

Fig 23. Penny Farthing

speed. The Michaux Company was the first to mass-produce the velocipede, from 1867-70. The velocipede marks the beginning of a continuous line of developments leading to the modern bicycle. (Imperial College London, 2009)

2.4.6 Penny Farthing

By 1870, metal working had improved to the point where the bicycle started to be constructed out of metal in Europe and the United States. The Penny Farthing bike, with the nickname “high wheeler”, was invented by James Starley. It was more comfortable to ride than its predecessor but it required acrobatic skills so its popularity was limited. The pedals were still attached directly to the front wheel with no freewheeling mechanism. Solid rubber tyres and the long spokes of the large front wheel provided a much smoother ride than its predecessor. Ironically the Penny Farthing’s popularity and use died due to another design produced by the nephew of its inventor, John Kemp Starley. (Lienhard, n.d.)

2.4.7 Modern Engineering

British engineers were next to pick up the design and improve upon it by adding ball bearings, pneumatic (Dunlop) tyres, wire-spoke wheels, a chain drive, variable gears and cable controls. In 1872 the German Friedrich Fischer first mass-produced steel ball bearings (patented by Jules Suriray in 1869). This was followed by Browett and Harrison, two Englishmen who patented an early caliper brake in 1876. Two years later, Scott and Phillott, who were also Englishmen, patented the first practicable epicyclical change-speed gear fitted into the hub of a front-driving bicycle in 1878. A year later, in 1879, Englishman Henry J. Lawson patented a rear wheel, chain driven safety bicycle called the “Bicyclette”. Thomas Humber, yet another Englishman, adapted the block chain for use with his range of bicycles in 1880. (Mozer, n.d.)

Meanwhile, the pneumatic tyre was invented in 1888. It was first applied to the bicycle by an Irish veterinarian who was trying to give his sickly young son a more comfortable ride on his tricycle. It has since become the universal norm for every kind of vehicle, including the bicycle. This inventive young doctor’s name was John Boyd Dunlop. (International Bicycle Fund, 1995-2010)

2.4.8 Rover Safety Bicycle

In 1885 the Starley Rover safety bike was born.

Fig 24. A safety bike

John Kemp Starley, nephew of the Penny Farthing’s inventor, used James Starley’s technology to create the Rover Safety Bicycle. As the name implies, safety bicycles were safer to ride than earlier models by returning wheels to a reasonable size and improving the bike’s stability. They had a saddle and handlebar grips, and the correct positioning of the crank axle made the bicycle easier to ride. A distinguishing feature of the safety bicycle was its cross frame with a tension structure. The seat height was adjustable, there was better weight distribution and a seat tube was added, thus creating the double-triangle diamond frame of the modern bike. This was the prototype for the modern-day bicycle. (Hudson, n.d.)

2.4.9 Mountain Bike

By the early 20th century, the bicycle’s design was developed and refined into a shape that made it one of the most popular modes of transport. The racing bike was developed in 1962 and the mountain bike was developed in Marin County, California in 1977. (Mozer, n.d.)

2.4.10 High-Tech Materials

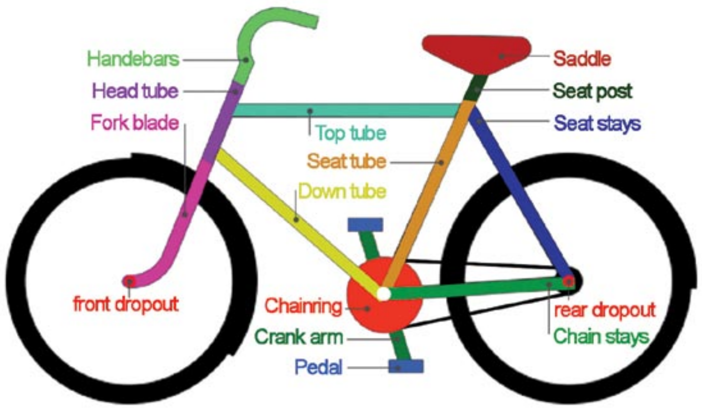


Fig 25. Bicycle parts

During the 1970s and '80s bicycle use exploded in popularity due to an emphasis on physical fitness, growing concerns about air pollution from automobile exhausts and the worsening energy crisis. The bicycle boom of the 1980s, led by Japanese and American companies, spawned the high-tech machines of today. (Hudson, n.d.) This filtering-down of technology means that sophisticated bicycles can now be bought for relatively modest prices. In the last two decades there have been many new materials developed and used, like carbon fibre and titanium, in an attempt to reduce the weight of the bicycle and improve its efficiency. However, along with the bicycle's technological advances came issues regarding the products' afterlife, and the restoration and maintenance of these bicycles require high-tech processes that have become harder and costlier for the users.

Bicycles are continuing to evolve to suit the varied needs of users and different parts of the bicycle are continually being refined and improved. In an effort to make bicycles more lighter, more reliable and more fun to ride more than ever before, designs and materials have been freely borrowed from the motorcycle world (disc break), sailing (carbon fibre construction) and the military (exotic materials such as titanium and magnesium). While all this research and development in design and materials has provided breakthroughs in bicycle use, the sheer cost of it has pushed many bicycle designs into the luxury market, making them affordable only to rich elite Westerners.

This research project continues to explore the bicycle's design and material capabilities but takes a different approach. This approach will explore the viability of using locally available materials and labour skills; simple and economical manufacturing processes; and a design that has multiple functional uses and is accessible to users in the lower income bracket in Third World countries.

2.5 Bicycle Ergonomics

Neuss stated: *"Ergonomics helps to improve the output and the comfort of bike riding. When improving the comfort, you can use your power more for bike riding and not for struggling against pain. When you improve your output you get more comfort because your muscles become stronger..."* (Neuss, 2007)

The term 'ergonomic' is a complicated word for a simple idea; it meanis "design work with the user in mind". Good ergonomic design can enhance productivity and the quality of a product but if a product fails in this regard it could mean it fails to achieve its potential. Bicycle ergonomics have come a long way since the bicycle was first invented in the 1800s.

In general, bicycle production has changed its focus from craft production to mass production in today's globalized flexible system. (Rosen, 2002) Bicycle brands have become tools of the marketing department, with production mostly focusing on not only better functionality but also manufacturing efficiency, lighter weight and lower costs. For example, the length of a bicycle frame is determined by the number of frames that can fit inside a 20 foot container. True bicycle design only happens for high-end models, with average models consisting of various combinations and configurations from the vast choice of standard bicycle parts which are adapted to copy current trends.

Nevertheless, the demand for ergonomically designed bicycles is on the rise. Evidence of this is seen by the increasing number and popularity of 'made to measure' services within the bicycle industry which are associated with health and performance. Similar design elements are also becoming noticeable in design practice.

Ergonomic designs are now frequently adopted by factories in order to reduce possible harm and to improve the efficiency of interaction between the machine and the operator. (Bridger, 2003) The type of design that considers the static geometry or dynamic response of the human body and psychological need and wants is referred to as 'human-centred design'. It is important that the Greencycle, besides being functional and usable, is also efficient and comfortable to use. That is: it must be "ergonomic."

2.5.1 Five Standard Sitting Positions (Fig 26)

There are five standard sitting positions when bike riding, these are:

1. The race position (for racing bicycle) reduces drag up to 90%. This riding position is continually being scientifically tested to achieve optimal speed output. (Grappe, et al., 1997)
2. The recumbent position places the rider in a laid-back reclining position which is very comfortable and has good aerodynamic advantages.
3. The all purpose position (for travelling bicycles) is a low or dropped handlebar design where the rider bends forward, using stronger muscles to reduce air resistance at high speed. This position is used for long distance road riding.
4. The Old Dutch position fits everybody. This upright riding position uses a wider and longer handlebar which reduces the reach distance from the seat and pressure on rider hands. (Neuss, 2007)
5. The modern comfort thinking position (for city bicycles) is similar to the Old Dutch position except with a higher handle bar.

So what is the perfect cycling posture? Good cycling posture is very different from good sitting or standing posture. A posture that is comfortable for sitting will not necessarily be comfortable when riding a bicycle. Correct cycling posture must facilitate the pedalling action and also enable the rider to cope with shocks from road irregularities. The ability to adopt a good posture on any given bicycle will depend on many aspects such as road conditions, the right type of bicycle for the task and the correct sizing, including fitting/adjustment of handle bars and the saddle shape and height.

Such was the case for the modern comfort thinking position, which was invented almost twenty years ago as the result of medical opinion on how to correct your sitting posture to avoid back pain. The rationale behind this position was to combine the hands-up position with straight and vertical sitting, which proved to be misguided. The problem with the modern thinking city-bike position is that too much emphasis is placed on relaxing the muscles. When the positioning of the handlebar is more than 10cm over the level of the saddle, the back muscles stop working because there is no demand on them. After a few minutes the back is relaxed and cannot maintain the erect position, which forces the top of the spine to slouch and form a bad curve which causes pain to the neck and back (Neuss, 2007)

According to White (2007), a comfortable position may prevent the rider from producing the required energy to move a bike forward over a less comfortable position. Bicycle fit involves compromises – between comfort and performance output, quick acceleration and handling stability, top speed versus “taking in the scenery”. So how do you choose the right bicycle? Perhaps you need to ask “What do I want to do with my bike?”

Even though the recumbent position has been proven to be the most ergonomic, comfortable and energy efficient riding position, it cannot be adopted for this research project. The reason for this is that when the bicycle is used as a work horse and is carrying a heavy load, the rider must initially use their whole body weight and strength to generate sufficient power to create forward movement.

This requires the rider to be in an upright standing position, using the handle bar and pedals for leverage to move forwards.

For this research project, the ergonomic design factors must take into consideration key elements of the user's traditional bicycle design (old bicycle type) as this is what they are used to.

Thus, the configuration of the old bicycle frame will become the basis for concept development of the proposed design.

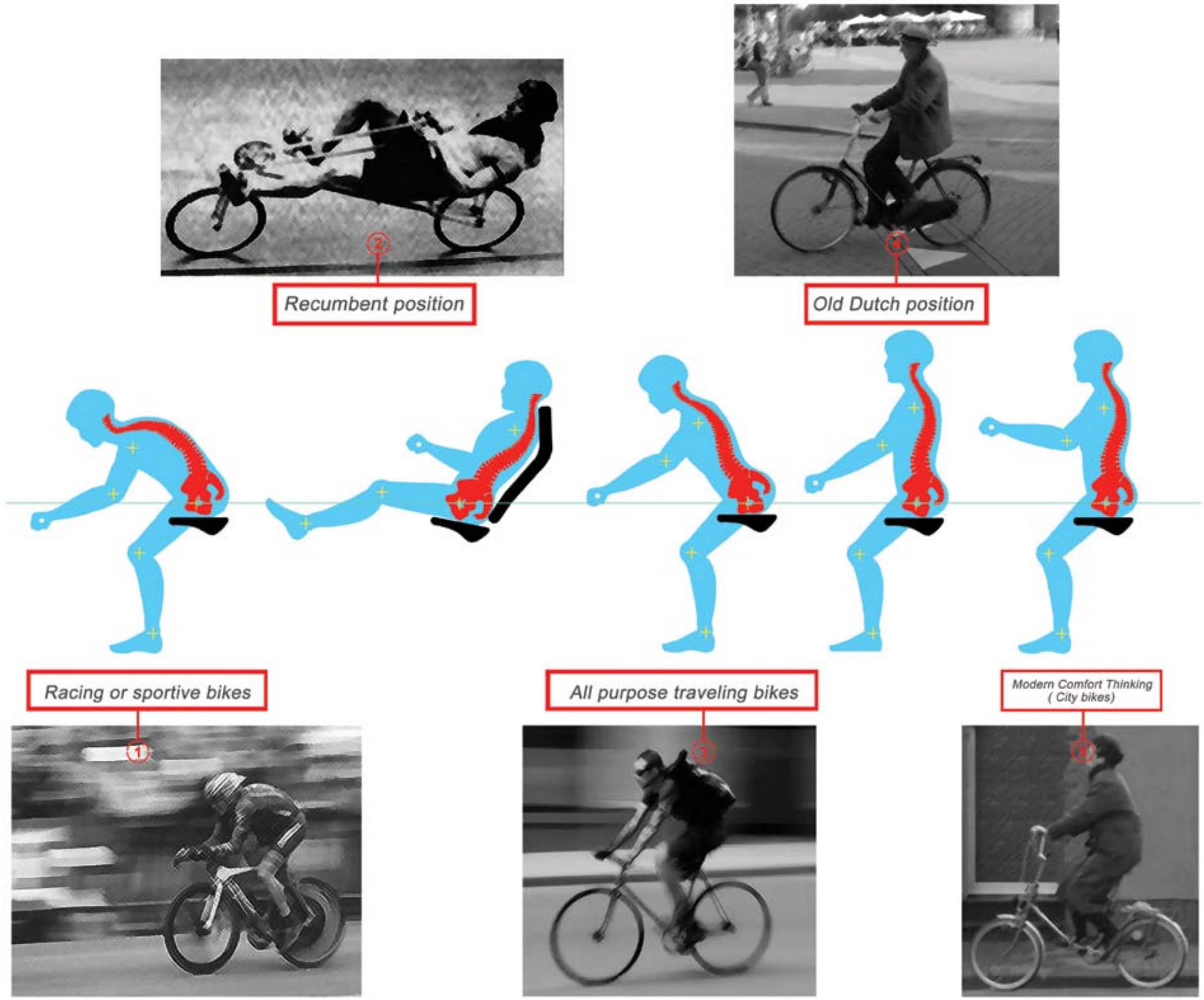


Fig 26. Diagram of five sitting positions

2.6 Construction Material for Bicycles

The pneumatic tyre and the chain drive, followed by the development of gears, revolutionized cycling in the later 1800s. Over the last twenty years, there has been a revolution in the use of new materials for building bicycle frames. It wasn't that long ago bicycles were made out of cast iron or even wood. German inventor Karl von Drais built the earliest bicycle; known as the "Swiftwalker" in 1817. This machine had no pedals and its frame was a wooden beam, with two wooden wheels with iron rims and leather-covered tyres. (Dodge, 1996)

Up until the time of the modern "safety" bicycle (developed in the late 1800s), most frames were made with steel tubing instead of wood or cast iron. While the steel bicycles were quite strong they were also very heavy. It was not uncommon for a bicycle of that era to weigh over 36kg. In the 1900s, higher quality bicycle frames were made of high strength steel alloys, or "chromoly" steel alloys which can be made into lightweight tubing with very thin wall gauges. However, the old chromoly was more prone to corrosion. (finishing.com, 2010)

One of the most successful older steels was Reynolds' "531", a manganese-molybdenum alloy steel which was introduced in 1935. More common now is the "4130" chromoly or similar alloy. Reynolds and Columbus are two of the most famous manufacturers of bicycle tubing. An example was the Schwinn Le Tour (on certain models), which used chromoly steel for the top and bottom tubes but used lower quality steel for the rest of the frame. (Lowe, 2010)

Steel frames are still commonly used today simply because of their low cost. Steel has the ability to be easily shaped and joined and it is the least expensive material for bicycle frame making. However, the tubing used today has thinner walls and so weighs considerably less and is cheaper in cost. Modern frame makers offer a variety of materials in highly specialized bikes such as steel, aluminum, titanium and even carbon fibre is used, depending on the type of bike, the rider's preference and the cost. (State Master.com, 2003-10) However, looking at current developments, it is possible that high strength fibre reinforced plastic may eventually win a place among the materials for bicycle frame construction in automated production as it is more economical.

There are other frame materials which have been explored by bicycle makers. In the 1870s, metal frame construction became dominant. However, there were regular revivals of wooden frames, including bamboo, until the end of the 19th century. Since the earliest "hobby horse" days around

Fig 27. The first bamboo bicycle

1817, wooden frame bicycles have been made and ridden with satisfaction at regular intervals. Various wooden frame bicycles dating back to the 1890s can still be seen at veteran-cycle rallies today. Wood was used regularly up until the 1930s for wheel rims, mud guards and seat pillars but the wooden frame only appeared in the 1940s. (Wilson, 2004)

Bamboo was introduced as a bicycle frame material in 1894 (English patent number 8274) and was shown at the London Stanley Show (1894) where it caused a sensation. These bamboo bicycles were advertised as being lighter and 'better than steel". Twelve models were offered by the company before it closed down in 1899.

Austrian company Grundner & Lemisch of Klagenfurt began producing bamboo bicycles in 1895, with bamboo from Shanghai. A test was carried out by the celebrated athlete Georg Jagendorfer, who weighed 125kg. Convinced that the bamboo bicycle would gain in popularity, the company opened a riding school in Vienna and formed the bamboo bicycle club "Mabbusradler" (the bamboo cyclist). (Dodge, 1996)

Fig 28. The Calfee bamboo bicycle

In the last decade bamboo bicycles have gained back their popularity. This has been motivated by the need to use sustainable materials. Many bicycles are being produced using bamboo as the main material by bicycle makers and enthusiasts. Craig Calfee started building bicycles out of bamboo for family and friends in 1998. These bicycles were such a success he began producing them for the general public in 2006 under the Calfee Design flag. (Elliott & Jablonka, 2009)

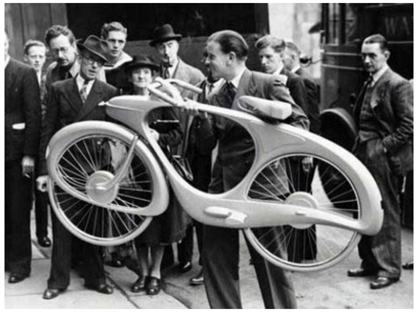


Fig 29. The Bowden Spacelander

There have also been several attempts to market a moulded bicycle frame. They are generally bulkier in appearance but more flexible than steel-framed bicycles. In 1956 a British engineer called Benjamin Bowden made one notable attempt to revolutionize frame construction with the "Bowden Spacelander", which was made of fibreglass. Only 522 units were produced by Bomard Industries of Kansas City, Missouri, in the 1960s, however a series of reproduction bikes were produced in 1985. (Herlihy, 2004)

Fig 30. The Itera plastic bicycle

In the early 1980s a Swedish company called Itera made an attempt to commercialize bicycles made entirely of plastic. Unfortunately it was a commercial failure and attempts to save the project were unsuccessful. Many of these bicycles were returned, mostly with broken plastic parts. Getting replacements was difficult as the parts were incompatible with other bikes. (Hult, 1992)

Today bicycles are made out of exotic materials such as titanium, aluminum alloys, nickel, magnesium and carbon fibre. Bicycle frames in the 21st century are lighter and stronger than ever before but are expensive due to the high material cost which only allows high income earners access to the benefits of these high-tech materials. For example, in 1992 the American Bicycle Corporation managed to produce a few bicycle frame samples made of Beryllium which achieved an astounding stiffness-to-weight ratio but came with a US$25,000 price tag (MOMBAT, 2010). Not only is Beryllium expensive, it is also toxic and these two factors alone render it essentially useless for most bicycle frame construction. However, with the advancement of technology creating new polymers and polymer-fibre combinations, recyclable polymers and improved manufacturing methods, there are certainly advantages for general use frames being made of inexpensive materials which last, are resistant to corrosion and also have a second life cycle possibility, as well as being friendlier to the environment.

For the purpose of this research project, bamboo as a bicycle frame material has the right qualities and has the advantage of being economical – bamboo is often an abandoned material in most Third World countries.

Innovation

12/92

ABM Beryllium Frame

Sorry, But This $25,000 Weightless Wonder Is Already Sold

■ *By John Kukoda*

Forget everything you know about exotic frame materials. Titanium? Vanadium steel? Advanced aluminum alloys? They're just so much mush metal compared to beryllium, a silvery-gray elemental metal that costs $300 an ounce. It's worth every penny to the aerospace and scientific communities, which until now have been its exclusive market.

While this price makes it a curiosity far out of range of most pocketbooks, there's a beryllium alloy on the horizon that might put a *one-pound* bike frame in your garage, without the need to remortgage.

Aerospace projects from Mercury to Voyager partly owe their success to the unique properties of beryllium. So do particle beam accelerators, experimental fusion reactors, x-ray machines, high-speed computers, and the inertial guidance systems of most missiles. Eventually, so will the Mach-25 National Aerospace Plane.

And maybe, if American Bicycle Manufacturing Corp. (ABM) succeeds with its bold plan, so will your future bike rides and races. Last year, the St. Cloud, Minnesota, maker of welded aluminum frames took its technology to the next level, displaying its first titanium mountain bike at the fall trade shows. But so did lots of other bike companies, and ABM's effort got lost in the flood of titanium frames, components, bolts and bars.

Not so this year. ABM's beryllium showpiece represents a milestone not just for the company, but for the world: the first recreational, consumer-oriented use of this metal.

The bike was developed as a joint venture with Electrofusion Corp. of Fremont, California, whose parent, Brush Wellman Co., mines and refines beryllium ore in Delta, Utah, and is the world's major producer.

"Two years ago, those guys wouldn't even have looked at a project like this," says ABM president Fred Schilplin. But the end of the Cold War changed this. "Other than satellite applications, their business is sliding away, so they're eyeing all sorts of other stuff," he says.

Based on beryllium's cost Schilplin hung a $25,000 pricetag on the aluminum-lugged, adhesive-bonded frame (and he already has a buyer in Germany). Paying for all the labor would double this figure, he says, but the engineers at Electrofusion were excited about the project and put in lots of "free" hours because, for once, they were making something they could relate to that wouldn't disappear into orbit or behind guarded doors.

Despite lightening tricks such as a fluted head tube and drilled dropouts, the aluminum lugs and fittings still weigh more than the one pound's worth of tubing. The green color is due to an aerospace epoxy coating.

JOEL BUTKOWSKI / COURTESY OF AMERICAN BICYCLE MANUFACTURING CORP.

BERYLLIUM 101

Compared to cutting-edge alloys of aluminum, steel and titanium which vie for incremental advantages in weight and stiffness, beryllium seems positively unearthly.

At ABM I hefted equal-length bars of these metals. Compared to steel, titanium felt much lighter, of course, and aluminum was lighter still. But the beryllium bar felt so unexpectedly, incredibly, impossibly light, I'd have believed the titanium sample to be steel and the steel bar, solid lead.

Beryllium's atomic number is 4, following only hydrogen, helium, and lithium on the periodic table. Its density (weight) is the same as magnesium's and a quarter that of steel's, less than half of titanium's, even less than aluminum's. Yet beryllium's stiffness far

exceeds that of *all* other metals, most carbon fiber, and silicon carbide-reinforced aluminum MMCs. With weight factored in, beryllium's specific modulus (the ratio of stiffness to density) is *7 times* better than that of steel, titanium or aluminum, all of which are essentially equal.

Although its tensile strength (resistance to breaking) falls between that of high-strength aluminum and some alloys of steel and titanium, beryllium is so light that adding extra material to increase strength still results in structures that weigh much less than would be possible with other metals.

For example, the 19-inch beryllium frame I rode in a technically challenging granite quarry in Minnesota weighed a paltry 2.5 pounds. This doesn't count its unflaggingly rigid, 1¼-pound titanium fork—itself a work of art by ABM welder John Jensen, who used a unique, sectioned crown and tapered blades formed from flat, welded sheets. Of the 2.5 pounds, however, the beryllium tubes accounted for just one. Each chainstay weighed a single ounce. The aluminum lugs, which Schilplin says were "way overdesigned" for this first prototype, totaled 1¼ pounds. The aerospace adhesive holding the frame together accounted for the other 4 ounces.

The rigid fork, combined with the frame's long, heavy lugs and equally overbuilt tubes (the down tube had a fat 1⅞-inch diameter that's appropriate for aluminum but brutally rigid for a material some 4.5 times as stiff), made the world's first beryllium mountain bike less than a joy on rough singletrack. Light, yes—the bike, with a Shimano XTR group and Magic Motorcycle cranks, weighed just 21 pounds—but too harsh for my tastes. It would benefit greatly from a suspension fork. Lacking one, I think smaller diameter tubes—maybe 1¼-inch down and seat tubes and a 1⅛-inch top tube (or even smaller all around)—would suffice.

The good news is, downsizing is easy. The tubes are individually formed from flat sheets and joined with epoxy seams. Thus, there are no diameter limitations as there are (or were) with titanium tubes siphoned from other purposes.

Welding beryllium is possible, even simple. Unlike titanium, it doesn't require an inert gas atmosphere to prevent oxygen contamination. The bugaboo of welding or even machining is toxicity. While most people aren't affected, about 2% of the pŏpulation are sensitive to inhaled beryllium vapors and particles, with effects ranging from respiratory distress to death. Thus, costly air evacuation systems are required, and ABM will have to install them if it goes into the beryllium business in a big way. Meanwhile, bonding pre-cut tubes is a safe alternative.

And right about now you're probably wondering, "What's the point of gearing up to produce $25,000 bikes?"

The answer is "albemet," an alloy of 38% aluminum and 62% beryllium. It splits the difference in density and stiffness between elemental beryllium and the other metals, still leaving it lighter and several times stiffer than anything else you can ride. It's also much easier to machine and weld, and—for everyone already drooling for a new beryllium bike—it's a lot less expensive, whether made into a TIG-welded, one-pound frame, a 3-ounce handlebar, a 27-gram brake bridge, or bar-ends that weigh one ounce apiece.

"The price [for an albemet frame] should be about one-and-a-half times what titanium goes for," Schilplin says.

That ain't cheap, but judging by the increasing numbers of road and mountain bikers willing to let the kids go shoeless for the "ultimate" advantage of titanium, another grand for a beryllium alloy frame that weighs a pound or 2 less seems like a sweet deal. My order is in. ■

Fig 31. ABM Beryllium news print from 1992

2.7 Bamboo

People who live in China, Japan, India, the Philippines, Thailand and Vietnam are intrinsically connected to bamboo. The Chinese respect and honour bamboo as a friend of mankind. To negotiate, to surrender, to continue ahead despite barriers, is the Japanese bamboo way. (Bess & Wein, 2001)

Bamboo is a survivor; it is flexible, resilient and persistent; it bends but doesn't break. Despite all these properties, working bamboo requires good craft skills and a proper knowledge of its qualities. Japanese craftspeople have been perfecting their techniques for hundreds of years, turning bamboo into elegant and beautiful objects. They have also learnt to manipulate the shape of bamboo. During the 1920s in the Kyoto region they developed a technique to create square bamboo. This process is most often used with large bamboo, in part because of its frequent end use as an architectural element which requires that size and shape. (Bess & Wein, 2001)

Fig 32. Square bamboo

To create square bamboo, the Japanese farmer places a four sided wooden frame carefully over the emerging bamboo shoot in the spring time. The frame height is about two meters and every ten days the frame needs to be repositioned, moving it higher up to incorporate the fast growing culm. The frame must be carefully sized; if too small, the sides of the bamboo collapse inward; if too large, the squaring effect will not be distinct. Because the weight of the frame can make the bamboo top heavy, the individual culms within the grove must be tied together to keep them vertical, making the process quite labour intensive. (Bess & Wein, 2001)

These creations have inspired this research project to explore similar techniques to create parts for the Greencycle from bamboo. This would not only create a better form which can be readily used and easier to construct, but also could improve the structure of the Greencycle. By being able to manipulate the growth of the bamboo into the desired form and length, this could reduce the number of joints, which would mean a reduction in construction time and cost.

2.8 Customized Bicycle

It has been more than 150 years since Scotsman Kirkpatrick Macmillan produced a bicycle with pedals and this

Fig 33. A custom-made bicycle

machine continues to evolve. Even today it continues to change shape, moving away from the traditional diamond frame, as designers use modern materials in the pursuit of better performance.

“Each frame is a step toward an understanding of a craft that takes a lifetime to master and remains difficult to perfect.” (Ira Ryan quoted in Elliott & Jablonka, 2009)

Almost all the bicycles available on the market today are designed to fit the “average” rider. They reflect significant compromises that the manufacturers feel are necessary to try and accommodate the largest number of people with the fewest number of designs, in order to reduce the cost of production. However, for the right price, there is no shortage of customized bicycles being offered in the market today. (Anderson Custom Bicycles, 2010) (Baum, n.d.) (Bob Brown Cycles, 2007) (Ira Ryan Cycles, n.d.) (Guru Cycles Inc., 2010)

The idea of customization is to make a perfect personalized bicycle that is a natural extension of the user’s body. Each bicycle is made to measure, designed and built to ergonomically fit that rider alone with the best materials they can buy. All this technology comes with a higher price tag and these customized bicycles are classified as luxury goods today, with only a small percentage of bicycle users being able to afford one. Nevertheless, most of this development pertains specifically to improvements in operation, personalized design and dynamics, while the function remains pretty much the same in essence.

Despite the long history and evolution since its predecessor the celerifere, a bicycle’s main function remains as a form of human powered transportation. Its other function as utility transport or as a work horse has also been explored – not only to provide extra storage but also as a people mover. However, the focus is very much on urban or inner city user needs instead of increasing the functionality of the bicycle’s uses based on the needs and wants of lower income bracket users particularly in rural areas, which essentially limits its potential as transportation to those who need it.

Having analyzed the bicycle in these various contexts, this research project is an attempt to use design thinking and innovation to improve on the bicycle and push cart forms, taking into account functionality, the needs and wants of the users, use of appropriate technologies and environmental sustainability while exploring the possibility of increasing the load bearing capacity and ensuring the safety of the user.

2.9 Bicycles in Third World Countries

The simple unembellished bicycle has become a symbol of the struggles of all hard working people in many developing countries. For decades, the “steel horse” has been the primary means of transportation for the average lower income worker to negotiate dusty roads en route to work, run errands and attend leisure activities. Even though bicycles are slow compared to motorized vehicles, they offer certain advantages, like being more manoeuverable in heavy traffic and being able to go where motorized traffic is prohibited.

In rural areas the bicycle has brought relief to those who would normally have to walk and carry loads on their head or backs. It has reduced the daily burden of carrying wood, water or farm goods to market and therefore reduced physical stress that can lead to health problems. The bicycle’s helpfulness can be measured by the amount it increases a person’s travel capacity – a function combining speed and load. However, in reality only one of its two functions is being fulfilled. In order to carry loads, most bicycle users have to sacrifice the bicycle’s primary function as a form of transport, i.e. they have to walk beside the cycle and push it while loaded. Some use a tricycle to increase bicycle efficiency but for poor users this is an extra cost they cannot bear.

Fig 34. Bicycle used as a push cart

Fig 35. Bicycle used as push cart

In countries which lack good transportation infrastructure, most bicycle users in the lower income bracket can only customize their bicycle using very minimal resources. They commonly use abandoned materials which they find such as off-cuts, found timber or ply wood to modify their transportation to suit their needs. Not only is timber easier to obtain, it is also easy to shape using only very basic technology.

Fig 36. Igorot transportation

Igorot tribesmen, Philippine natives from Banaue, use tree branches and trunks to build their entire transportation – with no engines or even pedals as they use their foot as a break. (Wood Culture, 2000)

Fig 37. Rwandan wooden bicycle

A similar vehicle to the wooden bicycle can be seen near Ruhengeri in Rwanda. Those who cannot afford bicycles simply build one. (Rwanda, 2003)

Tricycles are also common in Asian countries, adopted either for transporting passengers or equipped with platforms for hauling loads of up to 500kg. Pedal tricycles were first adopted in Singapore, followed by large cities in India in the mid-1930s. By 1950, pedal powered tricycles, variously known as rickshaws, trishaws, becaks or pedicabs, were in use in every city in Asia. The pedal powered rickshaw is still a common sight in many developing countries. Over one million are in use, with Bangladesh continuing to be reliant on the rickshaw as inner city short distance transportation today.
(Gallagher, 1992)

The reality is the poor cannot afford private cars nor can the very poor afford the small motorcycles that are now plentiful in many Asian cities. Furthermore, people who are economically, physically and socially disadvantaged are disadvantaged by a lack of transportation and by automobile-focused transport priorities that do nothing to meet their travel needs, especially those who live in rural areas.

Research carried out in 1990 showed that in the lower-middle-income city of Jakarta, 14% of households could afford only 20 bus tickets or less per month, and 40 percent could afford only 53, compared to the average household bus ticket usage of 101 tickets per month.
(Barter, 1998)

Fig 38. A rickshaw in Singapore

Small changes in public transport prices and service levels can make a big difference to the mobility of the poor. On the other hand, the bicycle has been around for decades and is a very reliable and economical form of transportation. It was the first wheeled machine ever steered solely by human power and it is perhaps for that reason humans have an intense affection for, and strangely specific memories associated with, the bicylcles they've owned. In developing countries such as India, parts of China, Africa and Indonesia, the bicycle plays a bigger role in the social structure and has been proven to be of key importance to their livelihood.

This highlights the need for a much greater emphasis on more reliable and economical basic transportation for the poor. Making non-motorized vehicles such as bicycles more affordable, functional, and sustainable to use, based on the needs and wants of the users and the environment, will benefit more than just the lower income bracket and has enormous potential in many developing countries and for the world in general. With the combined population of China and India alone being 2.4 billion, this research project could provide the framework and opportunity to bring about real economic and sustainable solutions.

2.10 Sustainability

The idea of sustainability is no longer a new concept; it goes back 40 years, to the new consent adopted by the IUCN in 1969. It was a key theme of the United Nations Conference on the Human Environment in Stockholm in 1972. The concept was drawn up to clearly suggest that it was possible to achieve economic growth and industrialization without environmental damage.
(Adams, 2006)

Sustainability has been studied and managed over the decades in many areas – including the environmental, social and economic. Sustainability issues are generally expressed in scientific and environmental terms but implementing change is a social challenge that entails, among other things, international law, urban planning and transport, local and individual lifestyles, and ethical consumerisms.

The sustainability movement has attracted many experts from different fields who have worked tirelessly for decades trying to come up with better solutions. There is no shortage of literature and programs to educate the public about the scale and urgency of the problem, including what can be done to live more sustainably. So why aren't we closer to solving the sustainability problem?

The challenge with sustainability is that expert opinion is not restricted to academic circles alone. Suitability is a complex issue. To be successful the problems need to be addressed systematically and holistically. To this end trans-disciplinary strategy needs to be adopted to enable researchers, practitioners and stakeholders to co-operate and address the complex problems.

It has also been suggested that the current process used by the environmental movement when resolving these issues is no longer adequate to deal with the problem. This process is called Classic Activism and is based on four simple steps:

1. Identify the issue to be resolved.
2. Find the right practices (if not known yet).
3 Spread the truth about the issue and the right practices.
4. If that fails, then urge and inspire people to support the right practices.

These four steps to solve many types of social issues work by winning over one mind at a time with the truth. Classic Activism works for simpler and more localized issues which have low change resistance or when the goal is changing social aspects of the issue. For example, it worked on getting smoking banned in public places and warning labels put on cigarette packets. In the environmental area, it worked on reducing city smog and making our drinking water safer.

However, when trying to resolve global issues such as sustainability, this Classic Activism formula experiences much greater resistance and a different set of approaches and more radical processes are required to achieve the sustainable result while maintaining the balance of society. Problems like climate change, deforestation, soil deterioration, chemical pollution, fresh water depletion, etc. are mostly caused by or are related directly or indirectly to the economic issue. (Rudel, 2005)

This research project aims to make a small contribution to the economic aspect of sustainability by increasing local productivity and creating new local income sources by increasing the functionality of human powered transportation and promoting greener use of materials.

Willard (2002) also stated that commitment to sustainability will only attain maximum benefits when it creates value and is fully integrated into business models, strategies and processes. Good environmental and social programs make good sense. When businesses give attention to and adopt more aggressive and creative environmental and social projects throughout their company's structure, this then creates a win/win approach for the corporate bottom line, the wealth of citizens and the health of the planet.

“Sustainability development” was the theme of Our Common Future, the 1987 report prepared by the World Commission on Environment and Development, commonly known as the Brundtland report. This report described sustainable development as “meeting the needs of the present without compromising the ability of future generations to meet their own needs”.

In other words, we should live off the Earth’s interest, not its capital. Sustainability development is like a three-legged stool. One leg represents economic prosperity, the second environmental stewardship and the third social responsibility. Therefore it is important to make sure all three legs are equally strong (Willard, 2002).

Using the Triple Bottom Line diagram of Bob Willard, the Greencycle used the triangulation of Environment – Economy – People to ensure reliable outcomes.

This research project also takes into account the four system conditions that echo the components of sustainable development and which have been used to accelerate the movement towards a sustainable society:

1. Nature’s function and diversity must not be subject to increasing concentrations of substances extracted from the earth’s crust.
2. Nature’s function and diversity must not be subject to increasing concentrations of substances produced by society.
3. Nature’s function and diversity must not be impoverished by over harvesting or other forms of ecosystem manipulation.
4. Resources are used fairly and efficiently in order to meet basic human needs worldwide.

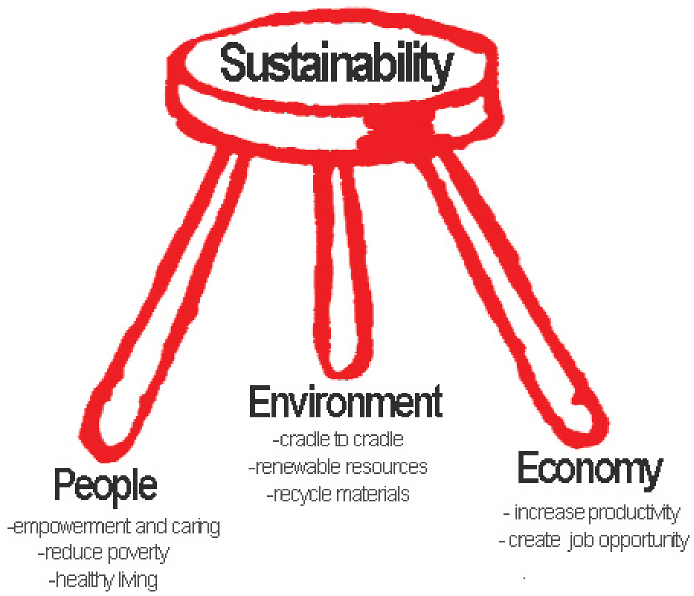


Fig 39. The Three Pillars diagram (Willard, 2002)

2.11 Designing in a Sustainable Way

Designing in a sustainable way means choosing the most suitable resources for a product and its function, not just satisfying the market trend. Good design is not only about showing off a product and enhancing its aesthetic. While operating within a set of social, cultural and ethical values, designing in a sustainable way must also take into account the relationship within which the products are generated. Therefore, based on the principle of the Triple Bottom Line, Greencycle looked at “The Sustainability Advantage of the Yriple Bottom Line” in the following ways:

2.11.1 Reducing the Material Intensity of Goods and Services

To reduce the number of material processes for the Greencycle, the possible use of bamboo as a key component was explored. While some manual labour is required to process this material, this is offset by creating jobs for locals and providing them with new skills and an income source.

2.11.2 Reducing the Energy Intensity of Goods and Services

The Greencycle is designed with materials for its main component use which can be manufactured locally and with minimal low-tech manufacturing processes.

2.11.3 Reducing Material Toxic Dispersion

As the worldwide population and prosperity increases, there has been a corresponding increase in the variety and amount of various materials used and the distances over which it is transported. Raw materials, minerals, synthetic chemicals (including hazardous substances), manufactured products, food, living organisms and waste are included. Sustainable use of materials has targeted the idea of dematerialization, changing the linear path of materials from extraction, to use, to disposal in landfill to become a circular material flow (called material flow accounting) that reuses materials as much as possible, much like the recycling and reuse of waste in nature. Dematerialization refers to the complete or relative reduction in the quantity of materials required to serve economic functions in society. In other words, dematerialization means doing more with less. (Wernick, et al., n.d.) So part of this research project explored and analyzed the use of a natural and non-chemical material as the main component of the Greencycle.

2.11.4 Enhance Material Recycling

The Greencycle concept was developed both to improve the functionality and usability of a widely popular form of local transportation in poorer Third

World economies and to explore greener and friendlier materials for sustainability purposes.
McDonough and Braungart (2002) proposed that we can be "wasteful" if the products we produce are completely reborn as new products or go completely back into nature. Using a cherry tree as an example, they note how "wasteful" it is. Each year it dumps a great pile of fruit and leaves on the ground to rot. But all of this waste goes back into nature to be reborn as new trees, bacteria, food for birds and other parts of the natural ecosystem. According to the authors, we should try to emulate this natural system instead of trying to do more with less.

Looking at the end of the life cycle, bamboo can be used as fire wood as an energy resource, for cooking and to warm up people's homes, as well as to provide light. The ashes then go back to the soil to replenish growth.

2.11.5 Maximize Sustainability of Renewable Resources

Bamboo is a fast growing type of wild grass that is widely available as an abundant renewable resource and which can be planted relatively easily. This eliminates the need to import raw materials, thereby reducing the carbon foot print. Utilizing bamboo as the main source material would encourage reforestation in an effort to restore areas of woodlands or forest which were destroyed some time ago for farming. (Johnson, 2009)

2.11.6 Extended Product Durability

Bamboo can grow as much as 60cm in a day and about 20-25m in a growing season. In its five year cycle, the plant can produce material as hard as wood from a 50-year-old oak tree. Bamboo can withstand pressure up to 26 tons. With a tensile strength superior to mild steel and a weight-to-strength ratio that exceeds that of graphite, bamboo is considered the strongest growing wood-like plant on earth, therefore it is an ideal material choice for the Greencycle. (Farrelly, 1984)

2.11.7 Increase the Service Intensity of Products

The design of other components that can be fitted onto the Greencycle frame to improve its function and use has increased the business viability of the project. This allows the user to customize and personalize the Greencycle to their needs, thus increasing their productivity. Studies have shown that there is a growing recognition that productivity is directly linked to the level of satisfaction and fulfilment that people get from their work. People who excel have a sense of purpose. (McNally, 2004)

2.11.8 Economic Opportunity

Dealing with the environment as an externality only creates a short term profit at the expense of sustainability and often leads to a decline in quality of life. However, a business that endeavours to meet the Triple Bottom Line can create value for customers, investors and the environment. A sustainable business must meet customer needs while at the same time treating the environment well. (Rennie, 2008) Creating a product that has a commercial value could lead to the development of small business, which in turn creates employment for locals.

2.11.9 Social Responsibility

This Greencycle project is a socially responsible endeavour. Social responsibility is the idea that future generations should have the same or greater access to social resources as the current generation. Social resources include ideas as broad as understanding cultures and basic human rights.

One of the aims of this research project is to empower people by giving them an opportunity to have control of this project by improving their working conditions and labour relations, reducing the visual impact of factory and commercial sites on the local landscape, helping employees develop transferable job skills and fostering community relations. Rom and Markowitz (2006) believe the environment plays a big role in the result of

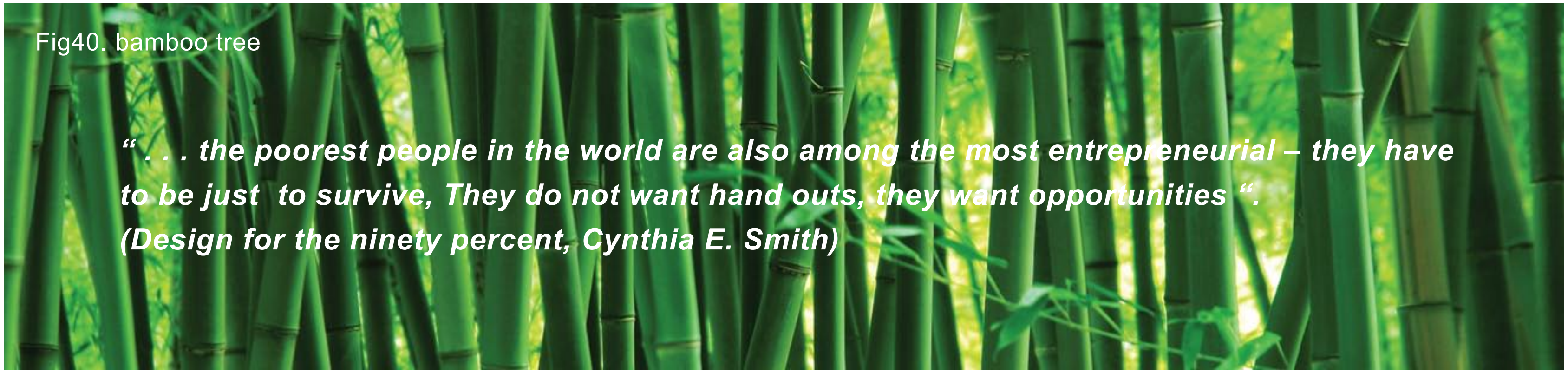


Fig40. bamboo tree

productivity. The following three aims help drive social responsibility:

1. Create sustainable solutions for the target demography by taking advantage of their biggest asset which is their land and their strongest skill which is basic farming.

2. Make this project as cost effective as possible, based on the standard of living of the target users who are poor framers. It is essential to develop a line of low cost parts that possibly can be manually produced thus making the Greencycle affordable. If the cost is low enough and the cost savings significant enough then it is more likely the product will be successful.

3. Create employment or to create local jobs. This will help to move as many people out of poverty for the least amount of money. It relies on the romantic notion that this project could be made by the end user or locals in their communities spread across the country. By providing an economic structure where they can learn skills, earn money and become self supporting over time would make this project more sustainable and diversify reliance on agricultural output.

2.12 Cultural Relevance in Sustainability practice

There are many different sustainability practices that have been alluded to in previous chapters that support the environmental movement. These practices range from reducing the carbon footprint, recycling, natural energy resources, renewable resources, reducing waste, etc. Universal thinking behind the word "sustainability" is always associated with the environment, however its very definition is difficult to clarify as it is expected to resolve many issues. On the other hand, it needs to be factual as well as scientific with a clear account of each specific objective. The simple definition "sustainability" is to improve the quality of human life while living within the carrying capacity of supporting eco-systems" (Gland, 1991).

There are two distinct problems that place pressure on sustainable development. The first problem is the resource and energy demands of industrial activity in developed and rapidly industrializing economies including worldwide issues relating to climate change, the depletion of the ozone layer, loss of biological diversity and increasing levels of resource consumption. This is also a fundamental issue on a national and local level connected to air and water pollution, land contamination, land fills and the accumulation of toxic materials in the environment. This requires a more technical solution and a scientific approach to the issue.

The second problem is the economical issue which has to do with the cycle of poverty, mainly experienced in third world and developing countries. This has resulted due to the rapid growth of populations causing a division of resources in which the population is disadvantaged of basic human needs such as food, shelter, health, education and family planning. The result of this has forced the needy to survive by exploiting the carrying capacity of their environment and in the process failing to respect its constraints (Roome, 1998).

The second problem needs more strategic thinking and a good understanding of human cultures in their specific or related region. “Culture” means different things to many people; in the broadest sense it means ‘values and aspirations, traditions and shared memories, the way to develop, receive and transmit these and the way of life these processes produce’ (City of Marion, 2010).

Fig 41. A plastic water jug in the middle of padi field

The aim of this research project was to look at both problems and explore the technical and cultural aspects of sustainable practice. While setting strategies in sustainability design is becoming increasing more important to minimize or eliminate waste and pollution, the implementation of sustainable strategies must be based on the cultural relevance of the users in Indonesia or other third world countries. In many cases, sustainable design strategies cannot be imposed on a Third World society without an insightful empathy for the culture or the “way of life” of the target population. It was also imperative to find the best practices to accommodate a triple bottom line of economics, environmental stewardship and cultural relevance to gain a true understanding of this green territory.

Throsby (2003-2004) stated that it is possible to develop a series of principles for development that can be regarded as culturally sustainable from the criteria that is inspired from an ecological or environmental perspective. There has been a widespread acceptance currently where human development should be the primary focus of development thinking.

The World Commission on Culture and Development whose report Our Creative Diversity was published in 1995, pointed to the significant cultural dimensions of a human-centred development paradigm and proposed bringing culture in from the side-lines of development thinking and placing it forefront as the main focus.

Capturing true cultural insights is about involvement, participation and co-designing approaches that have been sensitively and judiciously applied throughout the research, design and evaluation of the Greencycle project. This was to ensure that the ideation, design and development of the product would have functional, usable, commercial and cultural relevance and sustainability. Various human-centered research and design methods used in this thesis have been designed to capture cultural insights to inform the design and development of the Greencycle.

This research project has initiated and applied a human-centered design approached in all the stages of design development; from setting objectives and design criteria to conceptualizing design and developing the prototype and evaluating the results. Participation of the target user has been utilized as broadly as possible by involving them in the developmental stages of the prototype where understanding their individual abilities was necessary to prevent misconception as well as gaining honest feedback.

The participatory approach aims for reasonable consideration of all viewpoints in reaching reasoned and informed decisions. This human-centered approach has taken all factors into account; from the ability to source economical renewable materials to the ability to produce and manufacture based on the local skills and cottage industry, with a focus on the user's needs and wants. This approach has drawn on all relevant cultural knowledge and uses "expert" assistance with respect and sensitivity to the environment.

The next chapter details the Research and Design Methods that generated information and insight to inform the design of the Greencycle and components.

As alluded to in the previous two chapters, this research project is a multi-dimensional undertaking to design a functional, usable and sustainable Greencycle. Information and insights that are required to inform the design have to be generated from multiple sources. Trans-disciplinary research and design approaches involving human-machine-environmental interactions have been applied to inform, analyze, design and evaluate the Greencycle and the socio-cultural and environmental systems in which the Greencycle exists.

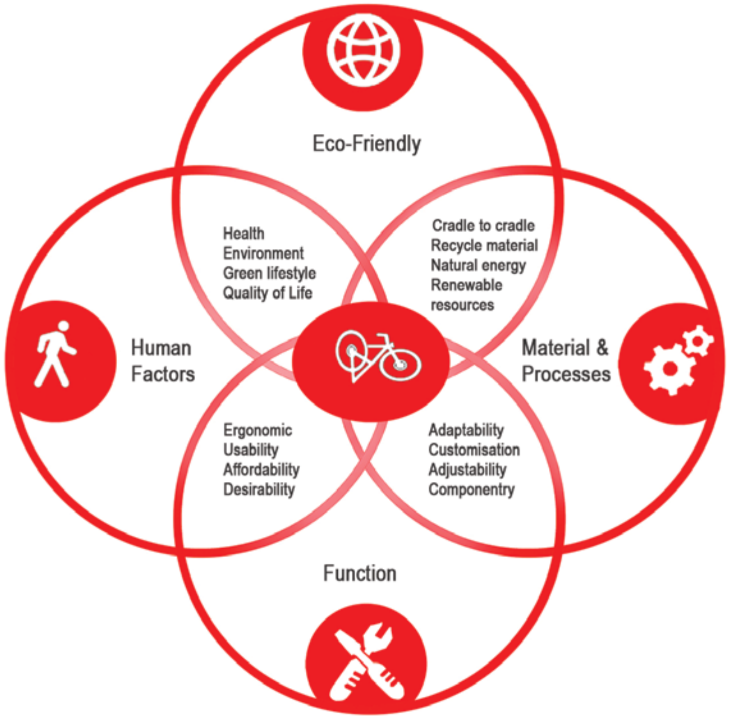


Fig 42. Diagram showing an integrated approach to the different design criteria of the proposed Greencycle (Maringka, 2009)

3.1 Human Centred Design Approach

Once, one of the world's greatest inventors said, "Give me a place to stand and a lever long enough and I can move the world." (Archimedes, c. 287 BC-c. 212 BC)

A human centred design approach is one of the key aspects of this design research project. Even though human centred design is considered one of the newer methods in research, most designers have adopted this method in their design processes. The focus of this method is to improve the usability of the product or service so that it becomes more personally related and meaningful to the user's life.

Human centred design methods have been used for understanding the users, for understanding their needs and wants for the product, for understanding how to implement this through design and for evaluating design ideas. (Jordan 2000). Understanding the relationship between the user and the product highlighted the needs and wants of the user which were then used as an insight in the design process. Human centred design methods were used throughout the planning, ideation and design development of the product. The objective was to provide the user with an improved and highly functional human powered vehicle to serve their needs, simply by analyzing, exploring, designing and evaluating a better product for users to achieve more efficiency in their daily chores.

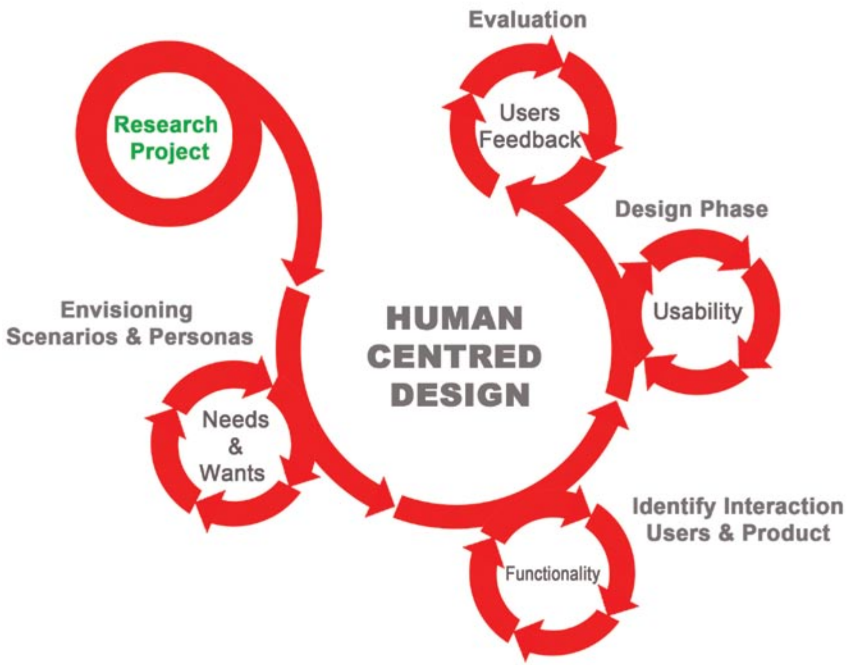


Fig 43. Diagram showing human centred design in the context of the proposed project (Maringka, 2009)

The human centred design method used in this project consists of the following four approaches:

3.1.1 Understanding the User's Needs

This research project began with the aim to improve product functionality, based on the needs and wants of the users. However, an aim is not enough to start a design process. The product has many different types of users, even though they are all in the same demographic. Therefore, it is imperative to accurately understand the end users' needs and wants. The research process relies on an iterative research approach to give insights into the users and their needs. The tacit knowledge of the researcher was used as a starting point to paint a picture of the needs and wants, however it was deemed important to use other methods, such as literature context reviews, personas and scenario building to give a much better understanding of the users and to ensure their needs and wants were sufficiently understood and transformed in the design.

3.1.2 Identify Interaction between Users and Product

One of the most important processes is transferring the understanding of users into design implementation. The key was to identify interaction first before starting the design process. The researcher summarized and synthesized the information from the literature context reviews, personas and scenario building which then fed into users' needs to establish product functionality.

This information was then used to guide the design process, especially to check if the needs of the user were being achieved.

3.1.3 Design

Using data and information gathered from expert interviews, the design ideas were generated, developed and improved with a focus on dimensioning, ergonomics, materials and processes. The functionality and usability of the Greencycle and accessories were explored based on product use. To prevent a premature single solution, the researcher used heuristic-generative methods when defining the solution, such as ideation, visualization, CAD modelling and 3D prototyping. The researcher also explicitly used two stages of prototyping – low fidelity and high fidelity. Low fidelity prototypes were used in the ideation stage which allowed for experimentation and rapid evaluation. High fidelity prototypes were produced in the final stage of prototyping to provide a final design which provided behaviour previews of the final product. Iterative user evaluation at both stages provided for fast and effective design feedback on usability, functionality, ergonomics and aesthetic requirements.

3.1.4 Evaluation

Drawings, mockups and prototypes have been used in the design process to validate and evaluate whether the needs of users had been met and to establish any changes or modifications that needed to be implemented to improve the final idea. Two key reviews are included; the usability of the product and ensuring the needs of users has been met by getting feedback from the users.

Fig 44. Woman with bicycle in Vietnam

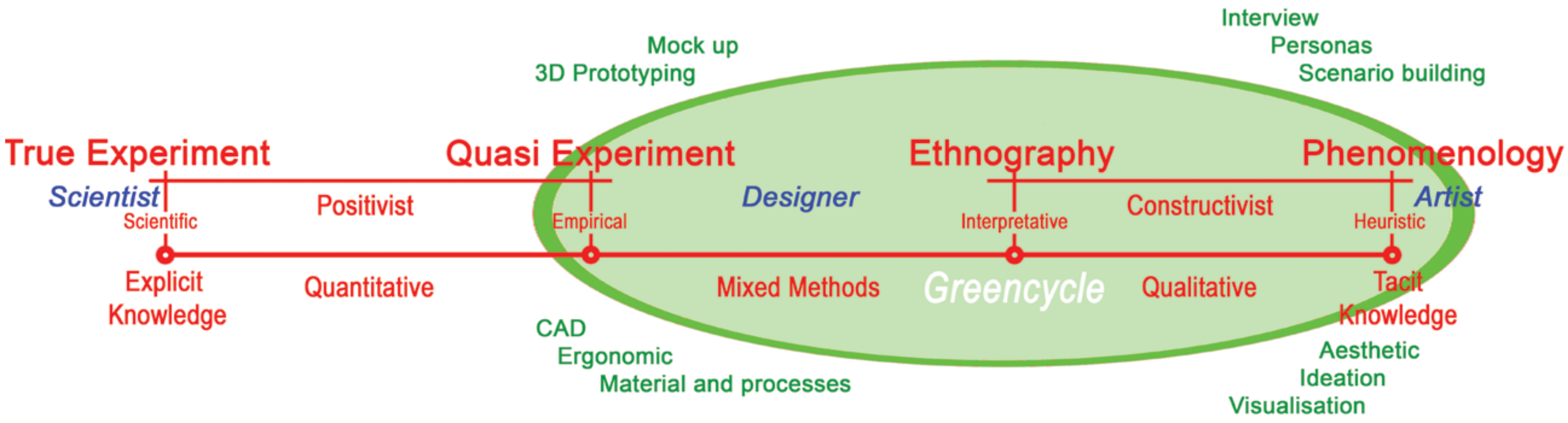


Fig 45. Diagram showing the research methodology of the proposed research design project (Adopted from Yap, 2009)

3.2 Research Paradigm: Phenomenology

A predominantly phenomenological paradigm is used in this research. The word paradigm first appeared in English language in the 15th century, meaning “an example or pattern”, and it still bears this meaning today. (The Free Dictionary, 2009) Today paradigms are used by researchers to help determine a theoretical framework in research projects. Paradigms give the researcher a basic belief system and thinking guidance that acts as a framework in selecting the type of methods which will help to examine questions. The research paradigm and methodology work together to form the research study.
(Mackenzie & Knipe, 2006)

Quantitative and qualitative research paradigms sit at the opposite end of the spectrum of the research framework shown in Fig45 (Yap, 2009). Even though qualitative research was the first form of social studies, it started losing its popularity in the 1950s and ‘60s as quantitative science research reached its peak. Qualitative research is normally used in the social sciences to explore people’s beliefs, experiences and behaviour in order to generate non-numerical information, while quantitative methods are used to gather and analyze measurable data.
(Mackenzie & Knipe, 2006)

Therefore, quantitative methods are seen as providing more representative, accurate measures through focused hypothesis. By comparison, qualitative methods are usually difficult to measure in mathematical terms. Quantitative research is commonly used by scientists while qualitative research is commonly used by social scientists who rely on heuristic and phenomenology or lived experiences to create their work.

However, professionals that are concerned with human experience, behaviour or emotion, such as designers and architects, tend to use a mixed method paradigm that incorporates both qualitative and quantitative research to provide the researcher with equally valuable data and information to inform the research study.

This research project has used mainly qualitative research with some quasi-experimental research to generate empirical information to inform and evaluate the design outcome (which also includes interpretative and heuristic-generative methods). This mixed method paradigm is advantageous and practicable because the methods form a "triangulation" to produce more rigorous and reliable design outcomes.

3.3 Research Methods/Methodology (Rational Methods)

The qualitative research method was used to gather information and data to generate an understanding and knowledge which then was analyzed to inform the design exploration process. In order to achieve this goal, it was necessary to gain a deeper understanding of the relationship between the users, materials, processes and their needs and wants concerning human powered transportation.

The research process consisted of six methods:

1. Direct observation
2. Literature context review (including internet ethnography and visual analysis)
3. Scenario building
4. Personas
5. Expert interview
6. Design evaluation

3.3.1 Direct Observation

The direct observation research method was used solely to identify the various modes of human powered transportation available to the lower income bracket in parts of Third World countries, such as Indonesia. This method was also used to gain information on human powered transportation and its relationship to users, as well as its uses within different natural settings. Direct observation

Fig 46. Diagram of Land based intermediate means of transportation in Third World countries

was conducted before starting more structured research to help form a research question.

Direct observation was considered to be more suitable for this research project as opposed to participant observation – this normally requires a long time for the researcher to gain acceptance and permission to participate in the culture or context being observed. Direct observation involves a more detached perspective, where the researcher is required to watch instead of participate, and technology can assist in the observation. Observational research findings are considered to be strong in terms of validity because the method allows the researcher to collect first hand information about particular behaviour. Trochim (2006) stated that validity is the best available approximation to the truth of a given proposition or conclusion. However, the researcher needs to be aware that there are problems with generalization. Findings in observational research may only reflect a unique population and therefore cannot be generalized to others. The study's findings would also be true for other people, in other places, and at other times. (Trochim & Donnely, 2006)

There is also the issue of researcher bias, where the observer may "see what they want to see", to overcome and avoid this issue in this research project, photographic image documentation was used for further analysis long after the observation.

3.3.2 Literature Context Review

This focused on the relationship between people and human powered transportation. Human centred design was one of the main aspects of this research and was employed to explore and evaluate the users' needs, the ergonomics involved, and the sustainability, functionality and desirability of the product in order to achieve the optimal outcome. Research included reviewing literature on different forms of human powered transportation to compare and evaluate what is currently available. This generated valuable insights into the needs, wants and desire for a more functional and sustainable type of human powered transportation.

Definition: Literature Review

The selection of available documents (both published and unpublished) on a topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is investigated and the effective evaluation of these documents in relation to the research being proposed. (Hart, 1998)

The benefits of a literature context review for this research project include:

- Highlighting the contribution of the research study to existing knowledge.
- Highlighting unresolved issues in the context of the research study and related case studies which then can be used as an aim of the research project.
- Collecting readily available information and data from related fields of study.

- Identifying and evaluating the needs and wants of the user, focusing on human centred design.
- Identifying the gaps of product knowledge which then can be explored in the design process.
- Finding the research problem within the framework and evaluate the theory behind it.
- Helping to refine the research project and suggesting the appropriate research and design methods.

3.3.2.1 Internet Ethnography

This is also known as online ethnography and involves a number of associated online research methods that adapt ethnography to the study of certain subject matter through computer mediated social interaction. Internet ethnography is one of the most practical research ways to get information on any subject from around the world. (National Science Foundation, 2001) These methods were used to explore and gather historical visual and written information on this topic which provided a good understanding of the relationship between people and transportation and provided additional information that contributed to the formation of the aims of this research project, as well as related case studies. Figures 46, 47 and 48 show some of the rich and diverse information gathered by internet ethnography.

• The hand made “Bamboo Cargo Bike” in Ghana by Craig Calfee, uses bamboo as the main component. Bamboo is plentiful and easy to grow in Ghana and can be cultivated in dry areas with minimal irrigation. Epoxy resin was used to join the bamboo together. Calfee stated that it required a significant amount of labour to produce and proper training of locals was needed for correct construction.
(Calfee, 2005)

Fig 47. “Bamboo Cargo Bike” in Ghana

This demonstrates there is still great potential to improve on this bamboo bike, maybe by simplifying the construction and looking at better ways to join the bamboo together, which would reduce construction time.

• “Bamboo Frame” by Brano Merres, who has also explored the use of bamboo as a material for his hand made bicycle. He managed to build the frame in a short amount of time by using a frame jig. He introduced modern materials such as polyurethane foam, carbon fibre cloth and epoxy resin which have increased the rigidity of the bamboo rod tremendously.

Fig 48. “Bamboo Frame” by Brano Meres

Unfortunately, all these added materials have made the bicycle non-recyclable and also increased its production cost.
(Meres, 2004)

• A non-profit organization in the UK called Carry Freedom has designed the “Bamboo Bicycle Trailer”, which is made of bamboo and can be built with minimal tool use. Carry Freedom’s aim is to design a bicycle trailer which allows bikes to tow up to 250kg for people with the greatest need for one but who have the least capacity to build or buy one. (Bamboo Bicycle Trailer, n.d.)

Fig 49. “Bamboo Bicycle Trailer” by Carry Freedom

As the internet has become increasingly ever-present in our daily life, the debate between online and offline research methods has increased. The internet has

made information readily available and easily obtainable by the simple click of a button. This provides instant information and knowledge on most topics. The internet has made primary and secondary research more accessible by increasing the number of platforms available such as case studies, blogs, chat room discussions, or news group postings. Compared to print, the internet has no limit to accessible information and can provide the most recent and latest information. A book needs to be identified before it can be obtained and all books take considerable time to be published.
The internet can locate information that is needed quickly and cost effectively.

However, the sheer amount of information that can be found in relation to the topic searched means the researcher has to exercise good judgment. Internet resources are not necessarily defined or rigorously processed, whereas book publishers provide guidelines for ensuring this. Establishing the quality of the resources found and verifying a publisher's credentials is important in order to avoid biased views or misleading information. However, in this researcher's opinion the lack of rigorous censorship on the internet has made the resources much more honest and spontaneous – they can provide the researcher with a more in-depth understanding of human psyches. It should also be noted that increasingly books and print publications can be accessed online, including out of print books or limited print textbooks, many of which might be almost impossible to locate otherwise.

3.3.2.2 Visual Analysis Methods

Visual collecting is a very important part of the design research process. The internet has made the use of this method more effective because it enables the researcher to obtain materials from wider sources quickly and cost effectively. Visual analysis has provided benefits to the design research study such as:

1. A historical visual review of human powered transportation used over the last 50 years in Third World countries, showing the way human powered transportation has gone through a

transformation process to suit the needs of the users. This information will provide the researcher with an understanding of the needs and wants of the users.

2. Understanding the user's interaction with human powered transportation where it has become an integral part of daily life in many parts of Third World countries. This information will provide an understanding of the relationship between bicycles and the users.

3. Understanding human powered transportation functionality and usability in Third World countries will provide an insight for the designer to explore various new ideas for the proposed project.

4. The challenge in visual analysis from the internet is maintaining the quality of the image as images come in various sizes, formats and pixel quality. An image which has been rotated and scaled from the original source will suffer some amount of artefacts or aliasing. To make the image useful, the researcher will be required to possess certain technical skills and software understanding. Another challenge associated with using images obtained from the net is the licensing issue. (Vincenti, 1999) However, many sites on the net offer readily available image services for a very small fee where most of the issues stated above have already been eliminated. This way the public gains the benefit by being given access to unlimited resources without the exclusion of time and location while publishers gain an advantage by reaching a wider market.

Fig 50. Relationship between human powered transportation and the user, and its transformation in Third World countries

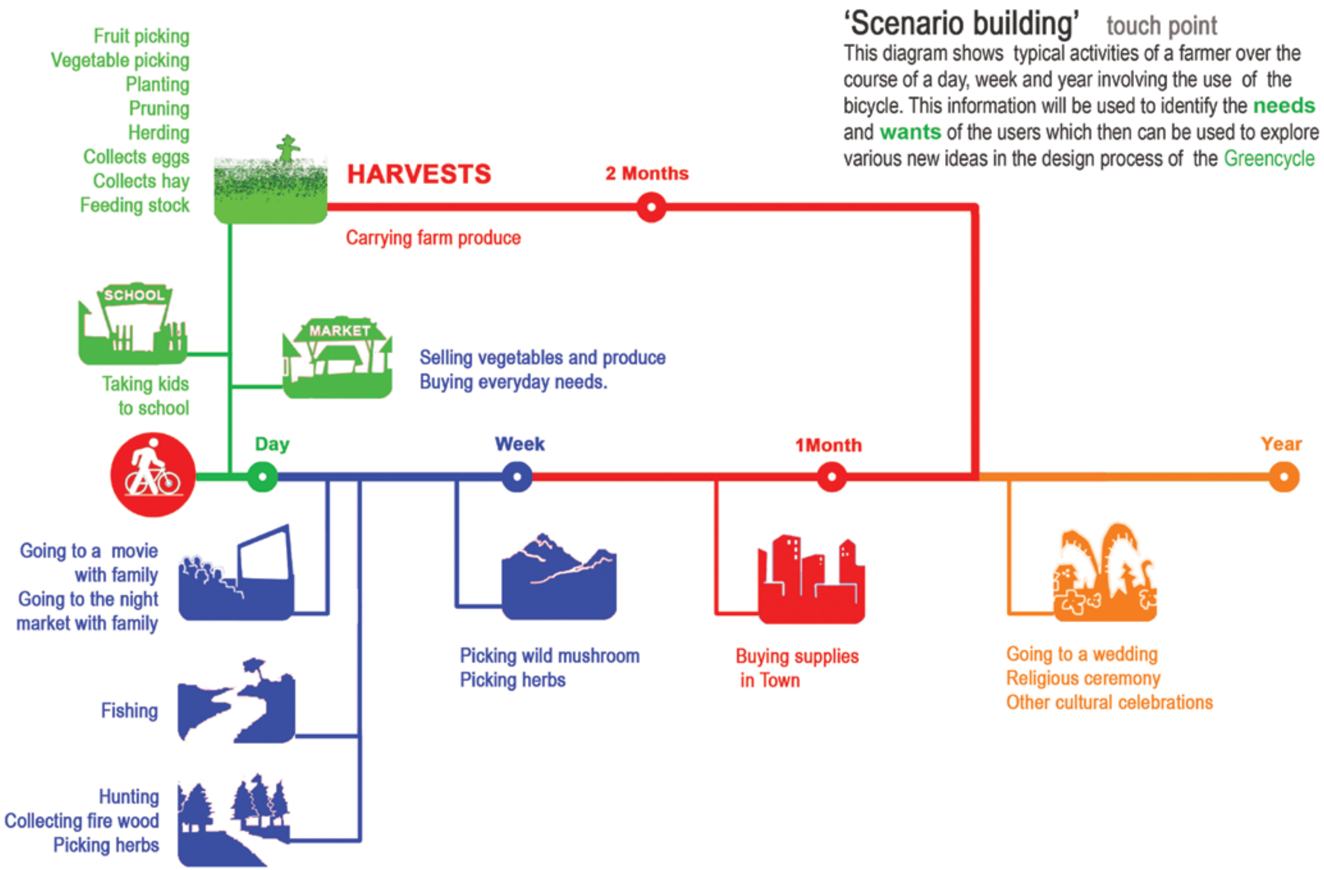


Fig 51. The diagram shows the scenario building of the proposed design research project (Maringka, 2009)

3.3.3 Scenario Building and Touch Point

The researcher was born and grew up in Indonesia and this has enabled him to build scenarios (tacit knowledge) and gather information regarding the relationship between man and human powered transportation, focusing on their functionality and usability. The scenario building method was more suitable for this project than interview or questionnaire methods because:

1. Literacy is one of the biggest problems for the targeted group.

2. The targeted group is in a different country.
3. The targeted group may not necessarily know what their needs are as they have inherited their living conditions and have adapted to their environment for generations.

The history of human powered transportation in Third World countries is quite straightforward but the functions are varied and filled with problems because of the different ways a bicycle can be used, from a work horse to use as transportation. The bicycle is also incredibly dynamic, each user tailoring it to his/her own needs. The research necessarily includes the entire history in order to understand the users and their needs.

Scenario building can use words or can be told with pictures to illustrate the users' journeys involving the use of human powered transportation.

3.3.4 Personas

These are representational characters envisioned by the researcher of the user profile, which were created using experience and tacit knowledge to represent the different bicycle user types within a targeted demographic. Personas helped to bring the targeted group, which is situated thousands of kilometres away, closer to the researcher and enabled reflection.

This provided a focal point in the critical thinking process and prevented biases from being formed. Personas were useful in considering the needs, desires and means of the users in order to gain knowledge and understanding to inform design decisions. Scenario building, personas and touch points form important mind maps to guide the designer to design and develop products and services which meet the needs and wants of the target users.

From an early age people use role playing and imagination as a way to explore the world around us. By pretending to be a different person we can try things out from that person's point of view, to find out if there is any difference in their viewpoint from our own. Role playing is a useful tool in a design process to explore and to identify certain information in one specific demographic group. Role play is a kind of persona building.

In the 1980s, designers at Apple used comic strips and play acting to think through the lives of their users and how they would integrate a variety of products, real and imaginary, into those users' lives. (Spool, 2007)

Adopting personas in a target role and representing behaviour patterns helped the researcher to see how the user related to the bicycle and the issues they might have. Personas are useful when considering the needs, desires and economic capabilities of users in order to gain knowledge and information which can assist making design decisions.

Personas represent behaviour patterns, not a job description (Goodwin, 2001), however it is imperative to give personas different job descriptions to gain an understanding of the product usability in wider applications within a targeted demographic.

Moreover, to use personas the researcher needs to be able to put them into a scenario which may come from the literature review, user research, tacit knowledge, usability testing or observation to make them complete. The scenario shows how they go from a picture to a real life character. (Quesenbery, n.d.)

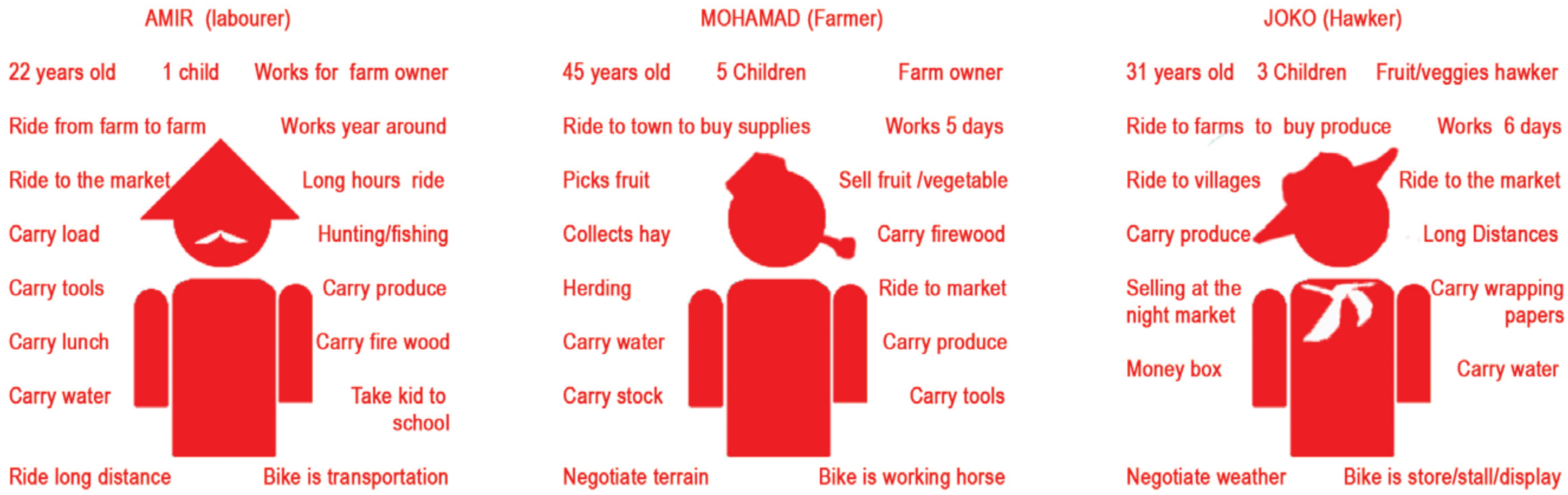


Fig 52. A diagram explaining the different needs of each persona (Maringka, 2009)

Using scenarios as a tool for storytelling will help include users in the design process and make them as real and explicit as the technical details. Therefore, personas will only work best with scenario building and walkthroughs; only then personas can bridge the gap between context of use and implementation.

3.3.4.1 Case Study: Fire Brigade Bicycle in China

Rural access roads in Third World countries are normally narrow earth and gravel roads which form the last link in the road network connecting rural areas to primary roads, and they can carry only light traffic. Therefore, access to some of these rural areas is very limited and this poses a real concern in the event of an emergency, such as a bush fire or when paramedics are urgently needed.

So in this case, three simple basic steps can be used to create the basis of this scenario:

1. Establish a goal and context. What makes the bicycle useful to the users?

2. Describe the usability. When, how and what is the bicycle used for?

3. End with result. Identifying the needs and wants of the user.

This information was then used to explore various new ideas in the design process of this proposed project.

Akira is an administration worker for a government office in a small town in China. He has also been a member of the volunteer fire brigade for a number of years. Akira and a few other volunteers are responsible for the neighbouring villages on the outskirts of his town.

In order to reach the hot spot in a relatively short time, he needs a simple vehicle to carry the firefighting equipment necessary. Because of the nature of the job, he requires a vehicle that can be used almost instantly and without having to rely on batteries or liquid gas. This means he can use the vehicle with ease and requires no special licensing to add extra costs for him.

With traffic congestion caused by the popularity of owning a personal car, he needs to be able to negotiate the heavy traffic en route to the troubled village. He also needs to be able to access the narrow roads in the rural areas or even use footpaths to get to the hot spot.

3.3.5 Expert Interviews

The 'experts' consisted of people drawn from related disciplines who were interviewed to help assess the materials used and the manufacturing processes. The interviews reinforced and validated the information and knowledge gathered from the earlier research methods, and everything was then analyzed, synthesized and used to inform the design process.

3.3.5.1 Participants

Four participants were recruited from four different disciplines, which were product design, product development, manufacturing and bamboo working. Participants were individuals who are active in their industry professions, all of which are related to one of the four discipline areas specified. Therefore, they possessed the right experience and current knowledge to provide a greater understanding of the issues around design usability the materials and the manufacturing processes.

Fig 53. Existing fire brigade bicycle in China

3.3.5.2 Invitation

Potential participants were contacted by a single email containing a letter and information sheet inviting their participation. Contact details were obtained from information held on the Designers' Institute of New Zealand (DINZ) directory. If the email was not responded to, then this was interpreted as the individual declining to take part in the study and no further contact was made. The purpose of and procedure for the interview was clearly outlined in the information sheet. If questions did arise, these were addressed via email or telephone. With both parties' agreement, a convenient interview date was established and the interview took place at their work or other suitable location. The participants were being asked to share their understanding and perspectives regarding issues surrounding usability, materials and manufacturing processes and how they might relate to design and the environment in a Third World country context. Participants were not asked to inform or influence the nature of the research, its aims or methodology, nor were they to have a formal role as stakeholders in the research. Their role was principally one of information sharing. Participants were not asked to take a formal role in the research outputs; however outputs of the research will be made available to all participants.

3.3.5.3 Interview Protocol

All responses and any subsequent discussion will be strictly confidentia. The interview material can only be accessed by the interviewees. Where information provided by the participant is published, the interviewee will be referred to as "Interviewee 1 . . . etc." or similar to protect anonymity. Their organizations will not be named. All participants will have the right to withdraw from the project at any time up to two weeks following the interview. Information and data will be kept/stored in the office of the researcher's supervisor in a locked cabinet at Auckland University of Technology for a period of 6 years, after which they will be destroyed.

3.3.6 Design Evaluation

The design evaluation is intended to evaluate whether the criteria have been met from previous research findings and to establish any changes or modifications that need to be implemented to improve the final idea.

Ten participants were selected and invited to enter into a consenting partnership to share with the interviewer their point of view on product prototypes based on their knowledge and experience. Potential participants were recruited from a targeted demographic whose livelihood and income is derived from bicycle use. They were chosen by a local leader who knows the background of the participants.

3.3.6.1 Participants background information

Participants were selected from the residents of Sukamakmur Village. Sukamakmur is located in the Kabupaten region of Karawang, about 70km outside of Jakarta (the capital city of Indonesia) on West Java Island, Indonesia. The landmass of Kabupaten Karawang is 1.753,270 km2 or 175.327 hectares which is mostly farm land.

3.3.6.2 Reason for Choosing these Particular Participants

The researcher was born and raised in Indonesia and has an intimate understanding (tacit knowledge) of the culture and is fluent in the native language. This and the fact that the people of Sukamakmur Village are farmers and heavy bicycle users are the main reasons for choosing this demographic group for the research project. The fact that the researcher and participants are all of the same nationality and speak the same native language will contribute to the success of the research. Besides the area's reasonably easy access, the population of Sukamakmur Village heavily relies on farming as their main income source. Their first hand experience and knowledge is ideal to be able to contribute to the evaluation of the design and usability of the proposed product. Based on information drawn from reviewing literature and journals (West, 1990), three important steps were taken prior to the interviews taking place. Observing these steps is imperative to show respect to the Sukamakmur community and culture and also to provide stability throughout the research project.

1. One month prior to the interview, a local leader was contacted through a local contact who had been fully briefed on the

research subject and invited the leader's participation. It needs to be noted that the local contact is a close friend of the researcher who shares the same interest in bicycles but is not a researcher, nor did he conduct any interviews. The local contact's participation was simply to act as a messenger in this research. The local leader is an official government employee who represents the people in the village. Having the support and personal involvement of the locally acknowledged leader greatly assisted in gaining access to the group of participants who consented to be interviewed. It is anticipated the same local leader will continue to lend support to the researcher as he implements his findings in the future.

The purpose and procedure of the interview was clearly outlined to the local leader when the first contact was made. The research aims and purpose were clearly laid out in the form of printed material in Indonesian. This was to provide a clear outline of the research project should questions arise. This material also highlighted the potential

Fig 54. Map of Sukamakmur Village on West Java Island, Indonesia, where evaluation was conducted

benefits of the proposed research project's outcomes. This allowed the local leader to advise the residents as to the purpose of the interview prior to the interview taking place. However, the researcher was conscious at all times that in conducting projects of this type of the need not to raise false hopes of change among the participants.

2. With the agreement of the local leader, a convenient interview time, place and date

Fig 55. Map of Sukamakmur Village in Kabupaten Karawang, Indonesia, where evaluation was conducted

was established. This was in an effort to avoid interfering in the daily prayer time and any other religious ceremonies which are considered sacred to the community.

The same local leader's assistance was anticipated when it came to gaining entrance into a research site, addressing cultural differences, identifying research participants who were literate and arranging transportation to isolated sites for the interview component of the process. Such assistance was crucial because having sufficient time to conduct the project is one of the many challenges most researchers encounter in field study.

Scale 3D prototypes of concept bicycles and accessories, along with visual aids to describe the functionality and usability of the proposed design were presented to participants throughout the interview process. This method of approach was simply to avoid alienation of any participant as illiteracy is the biggest challenge in the targeted group.

Two full-size working prototypes of a one wheel trailer were also presented and distributed to the target user from whom feedback could be gained at a later date. The participants were asked to share their point of view and perspectives regarding issues surrounding usability and functionality and how they may relate to the design and the environment in a Third World country context. Participants were invited to share their opinions to inform or highlight any issues with the proposed design and to suggest any changes or modifications that they felt needed to be implemented to improve the final idea.

Fig 56. A bicycle shadow

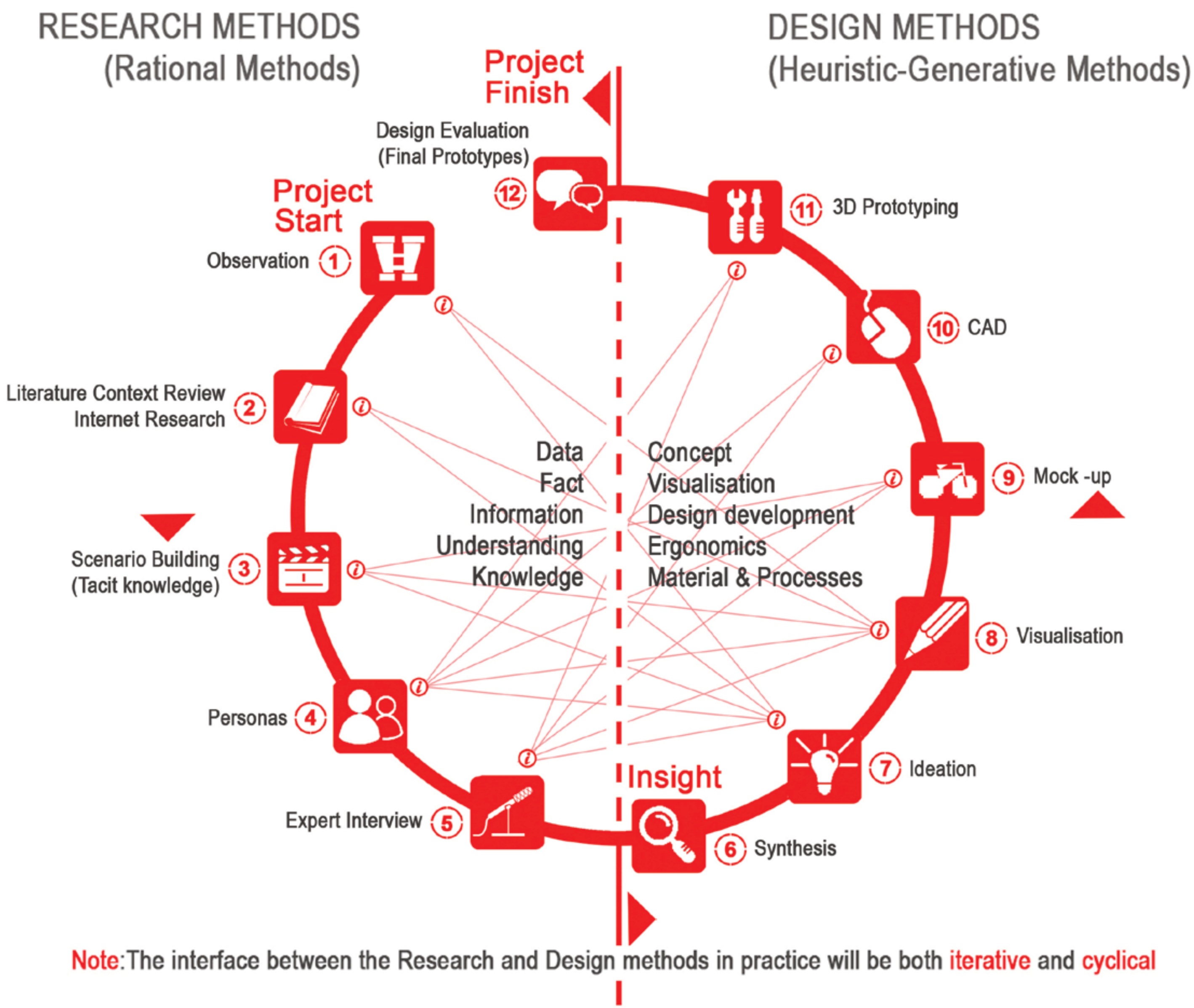


Fig 57. Diagram showing design research and design methods (Maringka, 2009)

3.4 Synthesis

To frame the needs and wants of the users to achieve the optimal outcomes proposed by the project. Synthesis is an important part of the research methods for this research project because more than two research studies were assessed with the objective of summarizing the data and information gathered from previous research methods.

Synthesis involves processing and interpreting existing qualitative data and adapting it to the new situation and set of data used in the proposed project. Information gathered from previous research methods can sometimes can be overwhelming. As access to research reports is sometimes haphazard and they can often be biased, it is imperative for the researcher to screen, interpret and summarize only the information that relates to this particular research project.

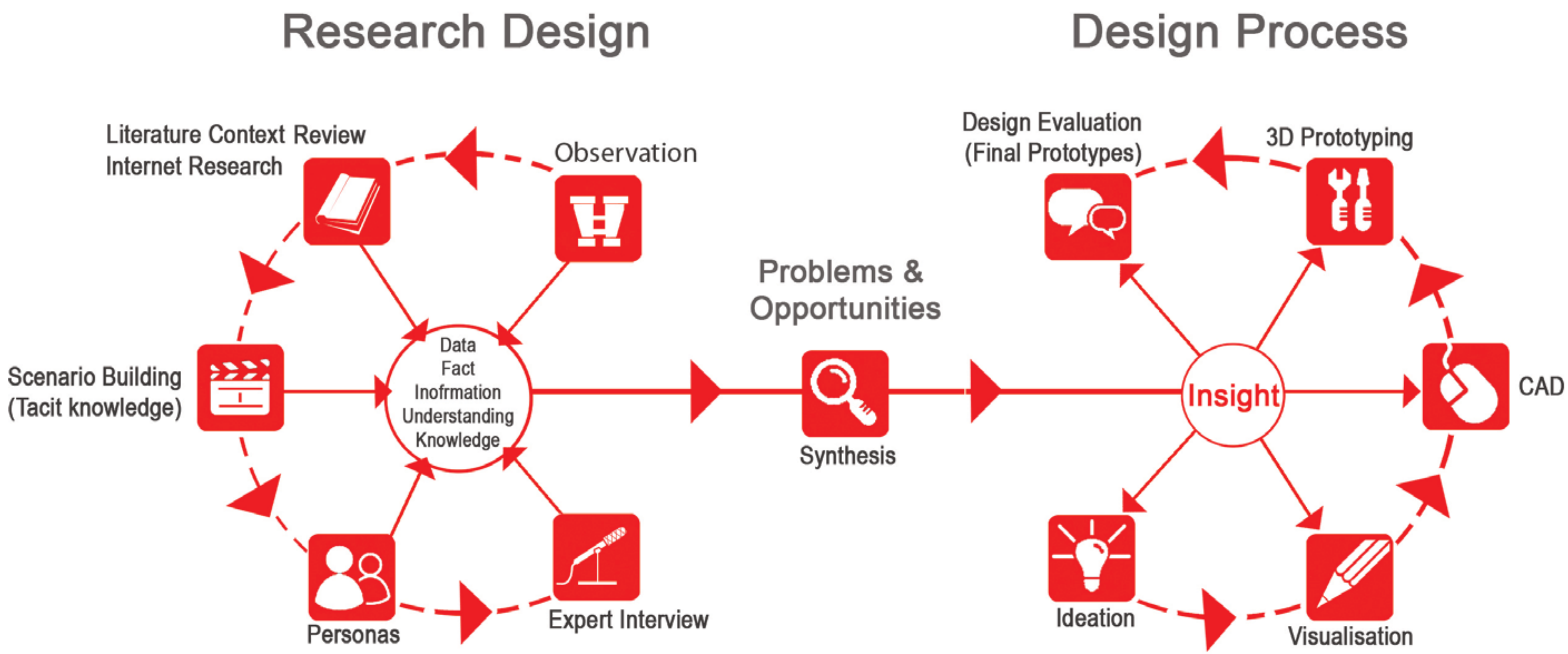


Fig 58. Diagram showing synthesis in the context of the design research project (Maringka, 2009)

Synthesis is often undertaken towards the end of the analytical process of a research project. However in the research design process, synthesis is more useful in the middle of a research project – not only to filter and summarize the qualitative information from previous research methods but also to frame the needs and wants of users, the usability and functionality of the bicycle and the materials and manufacturing processes of the Greencycle. This gives an insight into the design process, guides design development and assists with design evaluation.

3.5 Design Methods (Heuristic-Generative Methods)

Using heuristic, generative and intuitive methods, design ideas were explored using the knowledge gained from previous research methods and user-needs analysis. A list of function specifications, based on the information findings from the previous methods, acted as a guide to the design process and exploration. A series of new ideas on human powered transportation focusing on the functionality, usability, desirability, affordability and sustainability was developed.

Using the information gained from the mixed research methods, this was used as the basis to explore and develop the design ideas for a new hybrid form of human powered transportation. This encompassed the following heuristic and reflective approaches:

3.5.1 Reflective Practice

This involves the analysis of the problem and being able to revisit one's own experience critically, drawing conclusions and making decisions. Good designers are by definition reflective practitioners, looking for new ideas and improvements by reflecting and constructively analyzing their experiences and previous work. Experience can be a useful tool and important when exploring and generating ideas. Without experience, it is hard to

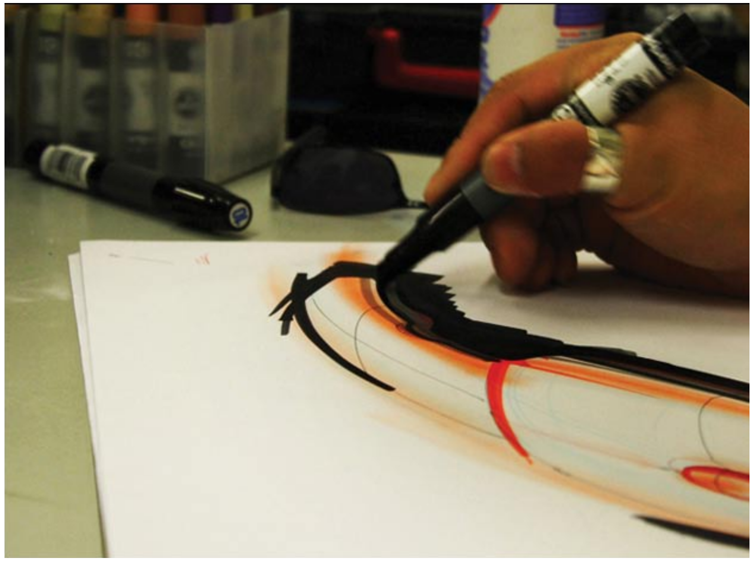


Fig 59. Reflective practice will help the designer to bring their knowledge to the current project and stimulate idea exploration.

contextualize, and this can lead to a lack of direction or thought. Experience gained through previous work will affect the decisions on new projects and will manifest itself as tacit knowledge. This becomes an insight for identifying new and better solutions and by doing so the designer develops their professional competence (knowledge, skills and expertise) in their own specialist area. A designer will continually reflect on their work and continue to do so throughout their careers as it is more about lifelong learning rather than quality assurance.

"When the practitioner reflects in action on a case he perceives as unique, paying attention to phenomena and surfacing his intuitive understanding of them, his experimenting is at once exploratory, move testing and hypothesis testing. The three functions are fulfilled by the very same actions." (Schon, 1983)

Reflective practice is applied in the design methods when the designer starts applying the heuristic method to explore new ideas informed by information and data gained from the research methods. In the ideation and visualization process, the designer needs to set goals to focus on the needs and wants of the users to keep it relevant and to avoid biases. However, to get the full benefit from reflection (and to be able to apply reflective practice to this project), the designer needs to be able to recall and make critical links from their own experience on what he/she has learnt from it. These experiences may be drawn not only from their best achievements but could also include the least successful ones – both types of experiences still contribute to tacit knowledge to show how decision making can be further improved upon at any achievement level. This will help the designer to bring their knowledge to the current project and use it to and stimulate idea exploration.

3.5.2 Ideation

Reflective practice was used to explore various new ideas that were informed by the data. Ideation also involves the use of imagination in an organizational context for problem solving in the conceptual phase.

3.5.3 Mind Mapping

Mind mapping was used to recall existing knowledge on a subject. This uses a diagram to represent ideas, tasks, or other information linked to and arranged around a central key word or idea.

Mind maps are used to generate visualized ideas and classify them. (De Bono, 2006)

3.5.4 Brainstorming (focus group)

This was used to help generate a number of ideas for the solution of a problem in the form of group creativity techniques. (Osborn, 1963)

3.5.5 Visualization

A series of pre-design ideas were analyzed, explored, improved and developed after the user needs had been established. These visual ideas provide a better understanding of aesthetic value and desirability.

3.5.6 Mock-ups (Scale Models)

A series of mock-ups of semi-working scale models were built to enable the designer to understand the entire product's workings and development which in turn gave a clear more realistic and animated concept (moving parts).

3.5.7 CAD

CAD software was used to give a more realistic representation to the design ideas. Using data and information gathered from interviewing experts and manufacturers, the design ideas were developed and improved with a focus on dimensioning, ergonomics, materials and processes.

3.5.8 3D Scale Model and Full-size Prototyping

Due to the wide scope of this project, several prototypes were built to explore different ideas. This process was necessary to provide a realistic representation of the proposed design ideas. This included:

- A scale model was built using SLA or rapid prototyping to illustrate the ideal bicycle to provide a realistic representation of a semi-working prototype.
- Two full-size, multi-function trailers were built and distributed to target users and feedback gathered to inform the future design idea.
- Two full-size bicycle frames made of experimental laminated bamboo were built to explore the possibility of using bamboo as a main material and utilizing local skills
- A full-size working prototype of the final design was built using current technology to explore the possibility of mass production, while maintaining a focus on affordability, the needs and wants of the target user and environmental considerations by using cleaner materials and processes.

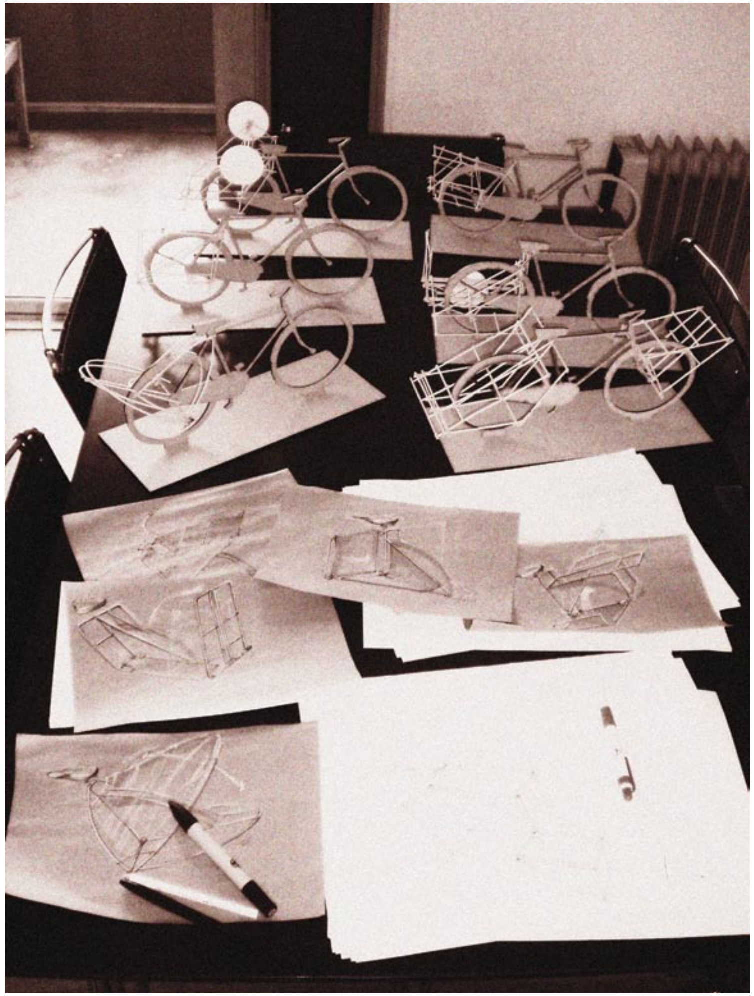


Fig 60. The preliminary scale models were used in the design accessories exploration

As outlined in Chapter 3, the significant findings of this research project have been derived from analysis of the data capture from the following six methods:

1. Observation (case studies are presented in detail in Appendix F)
2. Literature review
3. Scenario building
4. Personas
5 Expert interviews (interview transcripts are presented in Appendix G)
6. Design evaluation

Initially the research study focused on looking at how to improve the bicycle manufacturing process so that it was cleaner and didn't rely on unsustainable processes, together with exploring the use of renewable materials. Through the research study process and time spent in Indonesia, the focus shifted. It has become apparent that most bicycle manufacturers are only catering for the middle and luxury ends of the market instead of producing ranges suitable to and affordable for the people who need this form of transportation the most – the lower income bracket, whose livelihood depends on it to make ends meet.

Most target users cannot even afford to buy a bicycle and their needs have been neglected for sometime. Therefore, the focus of this research study changed to look at ways of reducing manufacturing processes and costs while utilizing local resources and harnessing local craftsmen's skills to produce a design outcome that will be best utilized by the target users to meet their needs and wants.

The Greencycle uses the the Triple Bottom Lines of Bob Willard (2002) to be socially responsible while designing for the other 90% in order to assist target users to become economically sustainable and reduce the environmental impact. This includes:

4.1 Environmental Issues

Bicycle transporters in rural areas can generally be categorized as middlemen. They purchase their loads directly from the farmers/producers in the villages and transport them to markets where they sell the goods onward to retailers. On the city outskirts, bicycles are used virtually for anything that generates an income – from a short distance taxi to the movement of goods, from door to door water and LPG delivery to selling food/drinks and vegetables, carrying farm animals (such as chickens, pigs, goats, etc.) and also services such as tailoring, kid's entertainment, etc. Bicycle use is more popular and prevalent in flatland areas than mountainous ones. Not only does demand on bicycle use encompass the many different needs and wants of its users, the bicycle also needs to be able to negotiate environmental conditions like traffic and variable terrain and this information was used as part of the design criteria.

The Greencycle research explored the use of abandoned local renewable materials such as bamboo as the main material, which is also less problematic to dispose of at the end of its useful life. By using bamboo strips, which are economical and readily available as a commonly used material in Indonesia (mainly for basket weaving) to construct the Greencycle frame, it is possible to use an economical green material that is biodegradable and can be used to reduce the cost of producing the Greencycle.

4.2 Local Resources

The various types of human powered intermediate means of transport in Indonesia make the best use of locally available resources, like recycled materials and user or craftsmen's skills in terms of modification and operational skills. These vehicles also provide a functional and economical means of transport as shown by all the case studies. Because they own it, bicycle users have generally been doing their own modifications to meet their needs as transport and as a way to make a living due to their limited financial resources. However, most of the work done relies on a very basic knowledge of materials and technology with very limited

Fig 61. Cottage industry in Indonesia

design resources. Interviews conducted with the two major bicycle manufacturers in Indonesia indicated that there is very little financial gain to be made in developing and producing these types of work horse bicycles as the target user is mainly in the lower income bracket and thus there is no interest in producing them in the near future. There seems to be no shortage in skilled craftsmen or blacksmiths in rural areas, so perhaps what's lacking is creative design ideas and choices. All rural bicycle users indicated they would pay a modest amount for a considerable improvement. As stated by Fisher (2007), the poorest people are also the most entrepreneurial, they do not want hand outs; they want opportunities.

Harnessing the local skills and resources to create the new bicycle this will empower target users in the lower income bracket to be independent and rely less on big corporations who focus on dollar value instead of the needs and wants of the target user.

4.3 Culture Agenda

Unlike the lower income bracket in Africa (Calvo, 1994), Indonesia does not have any cultural traditions against women riding bicycles. However, women on bicycles are still rarely seen on the street. The bicycle-riding woman in Case Study #5 (Appendix F) earned money from both primary and secondary sources of income and she used the bicycle mainly to go to and from work. She stated that in cases where there is only one bicycle in the household, women feel that it is only appropriate to let their husband's own it, even if it is only used for social purposes. They would feel wrong about owning and using a bicycle while their husband had to walk. So the best way to ensure that they would have access to a bicycle would be to have two bicycles in a household. However, this option is economically beyond the means of most rural households. Perhaps it is beneficial to look at ways of customizing these bicycles so they can be tailored for both male and female users and their needs.

4.4 Psychological Impact

Another area to consider is the psychological impact design modifications can have on the user's daily life and income. Humans need to work and have a sense of achieving something, not only in order to survive, but to be happy and feel fulfilled. To the worker, job satisfaction brings a pleasurable emotional state that often leads to a positive work attitude. A satisfied worker is more likely to be happier, creative, innovative and productive. However, it is important to note that the literature on the relationship between job satisfaction and productivity is neither conclusive nor consistent. Nevertheless, studies dating back to Herzberg (1968) have shown at least some connection between high morale and high productivity and it is logical to assume that more satisfied workers are more likely to add greater value to their jobs.

The fisherman can live with only a fishing rod and survive with such a simple tool, yet one suspects the fisherman would be happier to have a fishing net and better still a fishing boat. This is not something that has to be proven mathematically but something that can only be felt with one's heart or soul. While he can survive with his fishing rod, he can of course catch more fish with a net or a fishing boat and thus have a better life. It is logical to give rural people better tools, no matter how small the improvement may be, as this undoubtedly will have a far greater impact in all areas of their life and for their communities.

4.5 Old Work Horses

Only old bicycles, from the pre-1960 era, are commonly used as a working horse. They are old and rough but also tough and treasured. The sight of a bicycle owner washing their bicycle in the river every morning in rural areas is common. Most of these bicycles are passed on from generation to generation and are considered the most precious item in their household. Today the cost of one of these old bicycles is double or sometimes triple the cost of a new bicycle because they are considered antiques and are highly collectable. Due to this fact, to purchase one could cost the user up to two months of their yearly income. However, rural users think it is a good investment to own an old bike because they are robustly constructed and can take the heavy loads requiredm which justifies their purchase. It is safe to assume that bicycles in rural areas have become a valuable asset for the users and any modifications or improvements may not be readily accepted if it involved cutting, chopping or other desecration of their bike unless the necessary modification work was done prior to purchase.

The types of bicycles commonly found in rural areas in Indonesia are the 1940s Solinger (German), the 1940s Raleigh and the 1950s Hercules (both English), the 1930s Fonger (Dutch) and the 1930s Gazelle (Italian). Most common of all is the 1960s-1970s Phoenix (Chinese) simply because they are slightly cheaper and it is easier to obtain parts as they are still produced locally. These different models of bicycles all have similarities; a big steel frame and 28 inch wheel rims. One of the most important aspects of these bikes is that they were made to last with high strength low alloy steel which is often referred to as chromoly steel. (Welder, 2009). Therefore, it is logical to explore any design improvements that can be made with consideration of these old bicycles.

4.6 Business Model

To demonstrate that this is viable, three full-size prototypes were built to explore and analyze different aspects of the proposed design idea. The technology involved in design improvements should be easily adaptable to the local environment and knowledge conditions. Exploring local skills and the crafts industry and choosing readily available materials and parts not only helps to create jobs for local industry but also keeps the cost as economical as possible to insure product sustainability. (Cecchini & Prennushi, 2002) As a result of this process, it was realized that a small business plan could be developed to support and encourage local cottage industries. With the right guidance from the designer, it is now looking viable to have truly sustainable businesses not only in Indonesia but also for low income bracket users in other countries such as India and parts of Africa and China.

4.7 Key findings gathered from Expert Interviews

4.7.1 Restrictions

One of the aims of this project is to improve the functionality of the bicycle to help increase the productivity of target users in low income brackets. While conducting the expert interviews with designers, a common theme emerged where restrictions were identified and these need to be considered in the design process to ensure the usability of the Greencycle and its accessories. These restrictions are:

4.7.1.1 Modification

The purpose of design improvement or modification needs to be made as an extension or add-on of the target user's bicycle, with consideration to the integrity of the bike itself. Not only is the bicycle sacred to the target user but for most, the bicycle is the only means they have to make a living in their daily life. Any suggestion involving improvement or modification to their bicycle needs to be able to carried out in the shortest time possible. Work which may cause the absence of their means of transport will most likely face resistance from the target user unless new concepts/models of human powered intermediate transportation are created where modification or design improvement is made prior to the purchase.

Fig 62. Overloaded tricycle in China

4.7.1.2 Load Bearing Capacity

Increasing the load bearing capacity is one way to improve human powered, land based intermediate means of transportation. However, the limits of the user's (male) power itself needs to be considered and used as a restriction for any improvement. Increasing the load bearing capacity beyond the limit of the user's power will be totally pointless. A user centred design approach was used to explore ideas that determined

how improvements would be made based on the needs, wants and type of industry of the user. This approach helped to give assurance and anticipate or avoid operational difficulties that often are not examined until after a design fails to meet expectations associated with a product or service.
(Norman, 1988)

4.7.1.3 Bicycle Attachment

The proposed design solution needed to take into consideration existing types of bicycle. The design idea needed to be more specifically aimed at the target users. To design an attachment or an extension for general use on bicycles may present some issues because of the diversity of frame size and shape, material size and the geometry of the bicycles themselves as not all bicycles have the traditional diamond shaped frame. Two common attachment points for all add-on accessories are the rear wheel axel position and the under seat tube. These two points are consistently used on most bicycles for attachment solutions. However, there is a marked difference in the older type bicycle frame (pre-1970) to the modern ones of today.

Fig 63

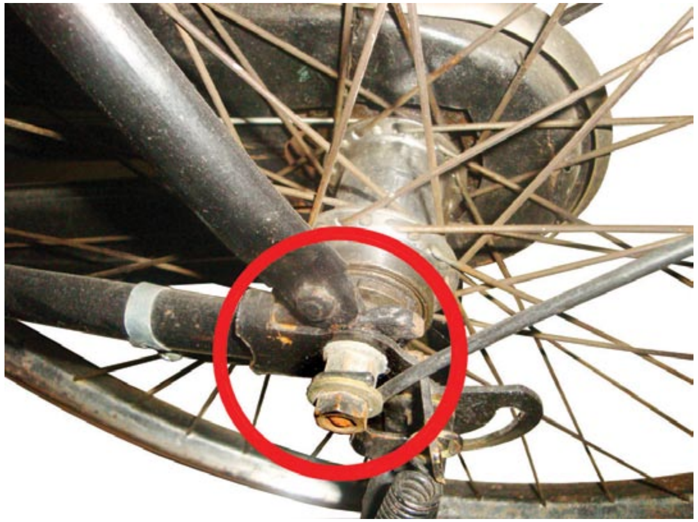


Fig 64

Fig 63. & Fig 64. Attachment points on an old bicycle

The older style bike has a larger frame and the configuration of the seat stays connects directly under the seat, whereas on modern bikes the entire frame has been lowered with a longer under seat tube which allows for a greater connection area for attachments. In older bicycles an attachment can only be fitted to a metal plate located between the two seat stay tubes above the rear wheel.

Due to there being only these two options where attachments can be connected, all attachment designs must take this into consideration. This makes any attachment solution problematic as originally bicycles were only designed to carry a rider and an additional pillion passenger, and never as a work horse to carry heavy loads. This issue became very apparent during the prototype user testing stage. However, proposed attachment point solutions have been created in the final prototype design.

4.7.2 Things to Consider

As a result of the expert interview process, other aspects had to be considered which have been used as design criteria for the Greencycle throughout the design phase. These aspects are:

4.7.2.1 Aesthetic Value

This may help to encourage the spread and uptake of the proposed design idea and create a certain sense of pride for the target users. However, the aesthetic value may only be of benefit to users who use their bicycles for trading and need to attract customers. For rural users, the emphasis needs to be more on functionality and usability based on their needs. A nice looking product without appropriate functionality to meet the user's needs would be useless. (Jordan, 2000)

4.7.2.2 Customization

This will provide usability options and flexibility to many users from different industries that have varying needs and wants. Customization will also allow users to choose an appropriate design to suit the task. However, customized systems will require the users to have a certain level of knowledge and skill. Not having these may result in some issues arising during the building process. To avoid this happening, the design of the parts and components has to be made obvious and easily identifiable.

Perhaps a guideline or template needs to be included with the proposed design.

4.7.2.3 A Modular System

This may help the target user to increase the load bearing capacity – this would save time, reduce the number of trips required and potentially increase their income. However, providing the user with the freedom to increase the load bearing capacity without any restriction raises safety concerns. To reduce this risk and keep within acceptable safety boundaries, perhaps having fixed sizes such as small, medium and large with load bearing capacities from 40kg to a maximum of 300kg will prevent the user from overloading the attachment beyond safe limits. This may provide a safety solution, however there is no guarantee about what the user may do in real practice. To find out more information about this, more field tests and observations need to be conducted over a longer period of time to collect valuable data from users.

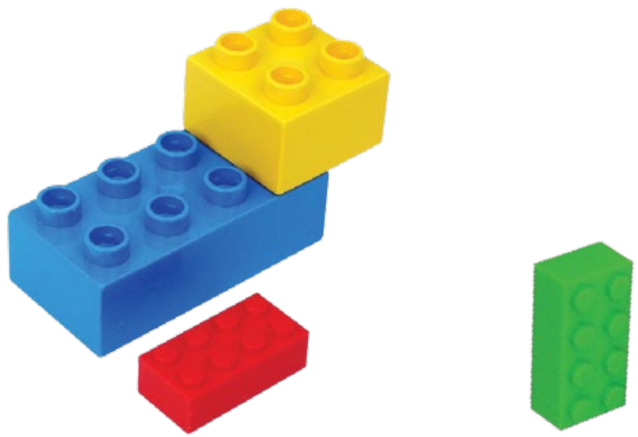


Fig 65. Interchangable lego bricks

4.7.2.4 A Folding and/or Detachable System

This could provide a good solution for users who use their bicycle for other purposes than work. Having a system that can be detached or folded to take up minimal space will allow users to utilize their bicycle as both a form of transportation and for leisure. Detachable and folding systems will also help users to negotiate traffic and not become a hindrance to other road users. For most users in the low income bracket, the bicycle is their only means of transport where they can take a loved one to a movie or take children to school. However, to create movement in an accessory system would bring an added complexity into the system and require more parts, which generally equates to greater cost.

There is also an element of where there are more moving parts, the greater the potential for things to go wrong or break down.

4.7.2.5 An Extra Wheel

Wheels can carry greater loads than hands so there is good reason to explore the use of extra wheels to improve a bicycle's use. Besides accounting for current road and traffic conditions, there are also road-user and local policy issues that need to be considered for rural target users when using a bicycle trailer. After going through the Indonesian Undang-Undang lalu-Lintas dan angkutan Jalan (Laws and Regulations of Traffic and Road Transportation, Tim 2009), no policy regarding trailer use on bicycles was found by the researcher.

4.7.2.6 Local Policy

With three-wheeled cycles being commonly used in Indonesia, it is hard to say if a trailer would be considered being a different type of human powered, land-based intermediate means of transport. However, the information from Case Study #6 (Appendix F) regarding trailer use needs to be noted and given due consideration during the development process. It seems incidents like this happen mostly on the city outskirts where perhaps those in the lower income bracket have become a soft target for corrupt officers. Regardless of this, further research is needed in this area.

4.7.2.7 Natural Materials

All experts favour the use of soft natural products or materials as they are light-weight, malleable, reasonably strong and can be compactly folded. This soft product can be produced economically by locals using natural materials such as woven bamboo strips, flax or coconut fibres, etc. These materials can be easily formed into different product shapes like a bag, sack or basket which can then be hooked onto a simple detachable frame connected to the bicycle.

Not only are these storage products already in common use and readily available in most developing countries, they are also breathable and suitable for storing farm produce. Using these types of materials can also support the local craft industry.

Fig 66. Woven bamboo baskets made in Indonesia

Fig 67. Woven rattan baskets made in Indonesia

There are seven phases in the design and evaluation of the Greencycle:

1. Mind mapping
2. Ideation
3. Mock-up
4. Design development
5. Ergonomic testing
6. 3D modelling
7. Full-size and scale prototyping

5.1 Mind Mapping

This method is used to recall existing knowledge on a subject. This uses a diagram to represent ideas, tasks, or other information linked to and arranged around a central key word or idea. Mind maps are used to generate visualized ideas and classify them. (De Bono, 2006)

By generating ideas in a radial, graphical, non-linear manner, mind maps encourage a brainstorming approach to planning and organizational tasks. Though the branches of a mind map represent hierarchical tree structures, their radial arrangement disrupts the prioritizing of concepts typically associated with hierarchies presented with more linear visual cues. Using this point of reference in brainstorming encourages users to itemize and connect concepts without a tendency to begin

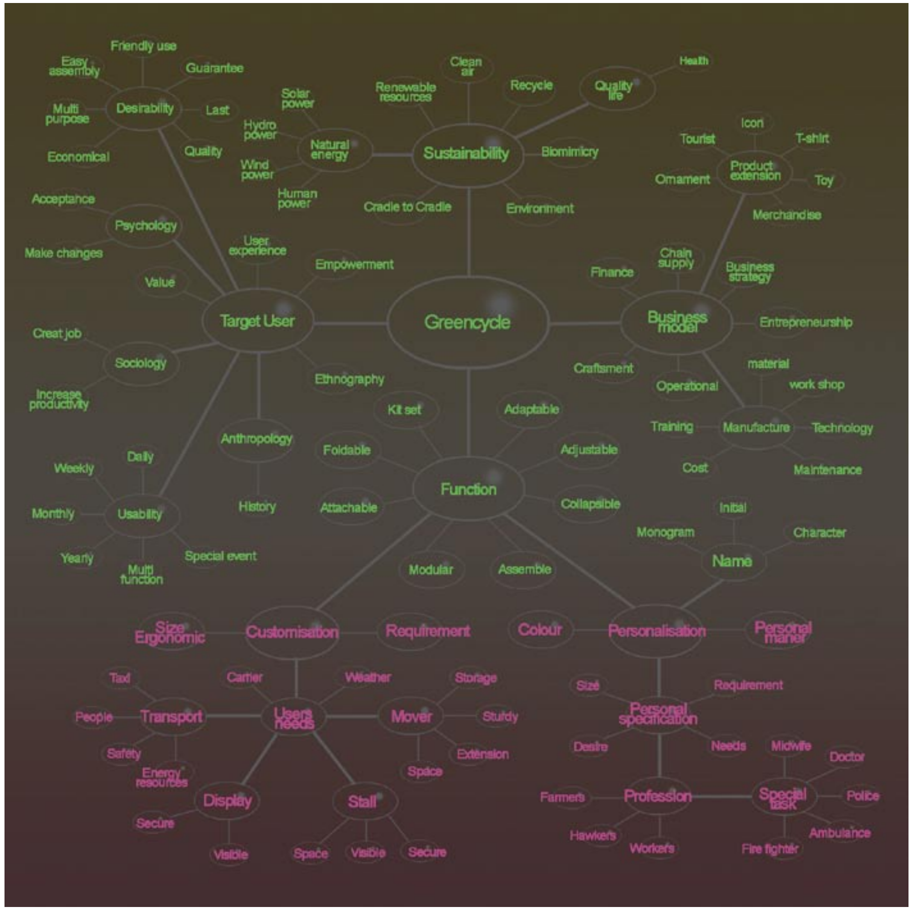


Fig 68. The Greencycle mind mapping diagram

within a particular conceptual framework. (Buzan, 2003)

To begin with, it is important to understand the meaning of the word ‘personalization’ and how to materialize the word. It means to take (a general remark or characterization) in a personal manner; to attribute human or personal qualities to;

to personify; to have printed, engraved, or monogrammed with one’s name or initials. (Farlex, 2010)

The word ‘customization’ means to make or change something according to the buyer’s or user’s needs (Cambridge University Press, 2009) or to make or alter to individual or personal specifications – to make to specifications according to requirements. (Blecker, et al., 2005)

5.2 Conceptual Design and Development of the Greencycle

Two main areas were explored at the ideation stage:

1. Exploration of new ways to increase the functionality and usability of bicycle in Third World countries or for low income users based on the needs and wants of the users.

2. Exploration of appropriate materials and perhaps new technologies for Greencycle which will be discussed further in the next chapter.

The conceptual design process involves the following steps:

1. Define the main aim of the product concept. Provide a short statement about what the product is and what its not and clarify the boundaries of the product application and the users’ needs of the product.

2. Describe user needs and wants. Using personas, describe who the target users are (such as Hawker, Carrier or Farmer), what their roles are in their use of the product and their individual need requirements.

3. Define and prioritize measurable aims and restrictions. Aims for the target user as intended by the designer are:

    - To increase the functionality of the human powered transportation in Third World countries.
    - To incorporate all the advantages and positive aspects of the bicycle and push cart.
    - To explore ways to customize and personalize Greencycle to meet the needs and wants of the users.
    - To explore environmentally friendlier and more economical material and manufacturing processes.

4. Produce a series of new ideas. Provide a series of sketches of proposed products the user needs including details of their attributes, features, functions and relevant relationship to the user.

5. Design the user’s task model. This is a list of all tasks the user needs to perform and how to perform each task using the product.

6. Synthesize proposed ideas. Organize proposed ideas

according to its functionality and usability. This provides a rough outline of the product to guide the detailed design phase.

7. Evaluate each proposed idea against the objectives. Various evaluation methods, such as heuristic evaluation, the reflective method, prototype testing and expert interviews are selected to measure or eliminate proposed ideas for the next phase.

Concept design or ideation is the very beginning of the design process, to explore a series of different possible directions very quickly before committing to one or two specific options. Exploring an initial concept helps to create the strategy and design solutions for that concept based on an understanding of the concept, user needs, and product constraints and beyond. Concept design is great for helping to quickly brainstorm various different approaches to a problem at the beginning of a design process and also for giving shape to the product and service innovations. (Institute of Design at Stanford, n.d.) Conceptual design is a very fast and cheap way to illustrate a new idea, since most people can draw boxes faster than they can build models. However, they do have their limits for conveying certain information.

One of the biggest problems with hand drawn sketches on paper has less to do with product functionality and more to do with one's work flow as a designer. Sketching something quickly on a piece of paper can be quick, but the problem is that it doesn't explain the products moving parts. Drawing arrows and lines all over it is one way to explain the direction of the moving mechanical parts but that quickly gets messy and doesn't give the full picture of the mechanical flow and how it fully functions.

Fig 69. Image 1 of Greencycle concept

5.3 Bamboo Frame Concept Development

Based on the The Sustainability Advantage: Seven Business Case Benefits of Triple Bottom Line (Willard 2002), a series of new preliminary ideas for the bicycle frame were explored, focusing on the possibility of using laminated bamboo strips as the main material which would be connected by steel joints.

Concept sketches started with basic side-view bicycle frame diagrams. All concepts were given a longer wheel base to create more possible storage space. However, to ensure the integrity of the bicycle's geometry, template triangulation between the handle bar to the top of the saddle and the centre of the bottom bracket of a diamond frame was used as the basis of each design idea. Seven concepts were chosen to be developed further.

Saddle height: The distance from the centre of the bottom bracket to the point of reference at the top and centre of the saddle.
Reach: The distance from the saddle to the handlebar.

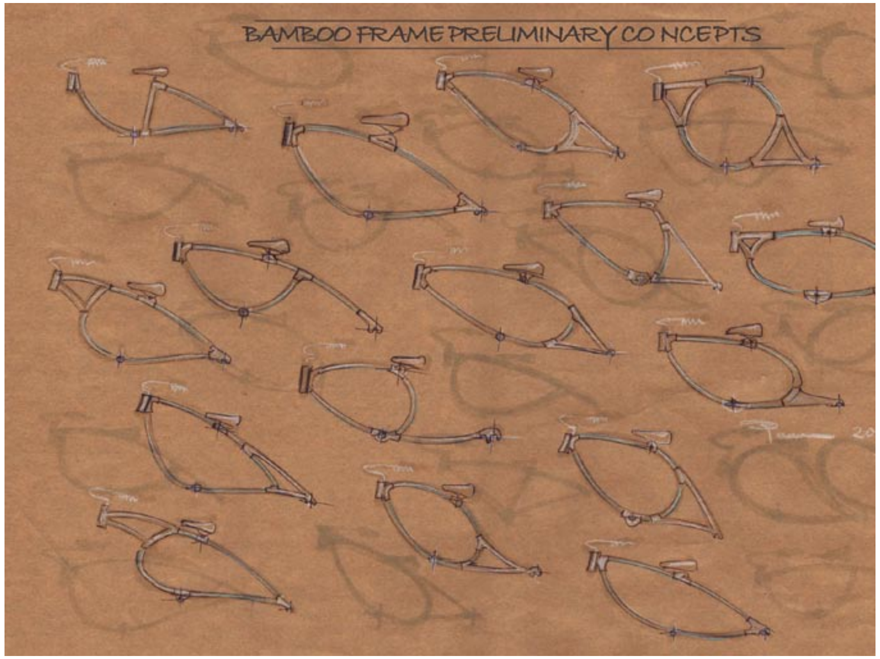


Fig 70. Preliminary bamboo frame concepts

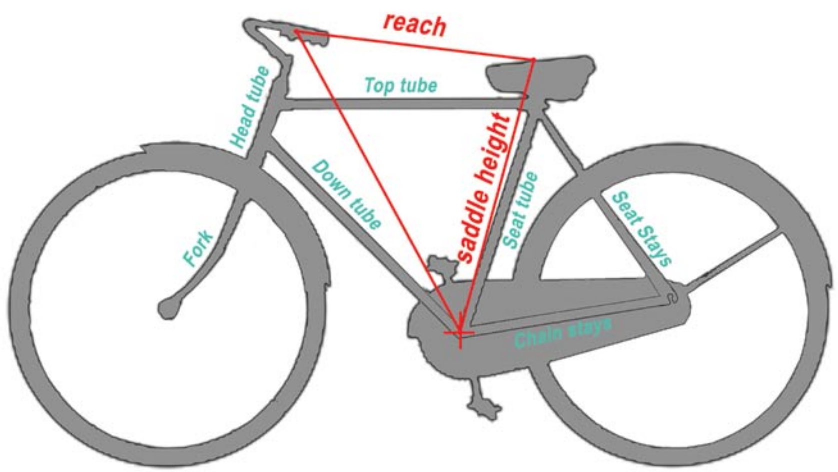


Fig 71. Old bicycle geometry

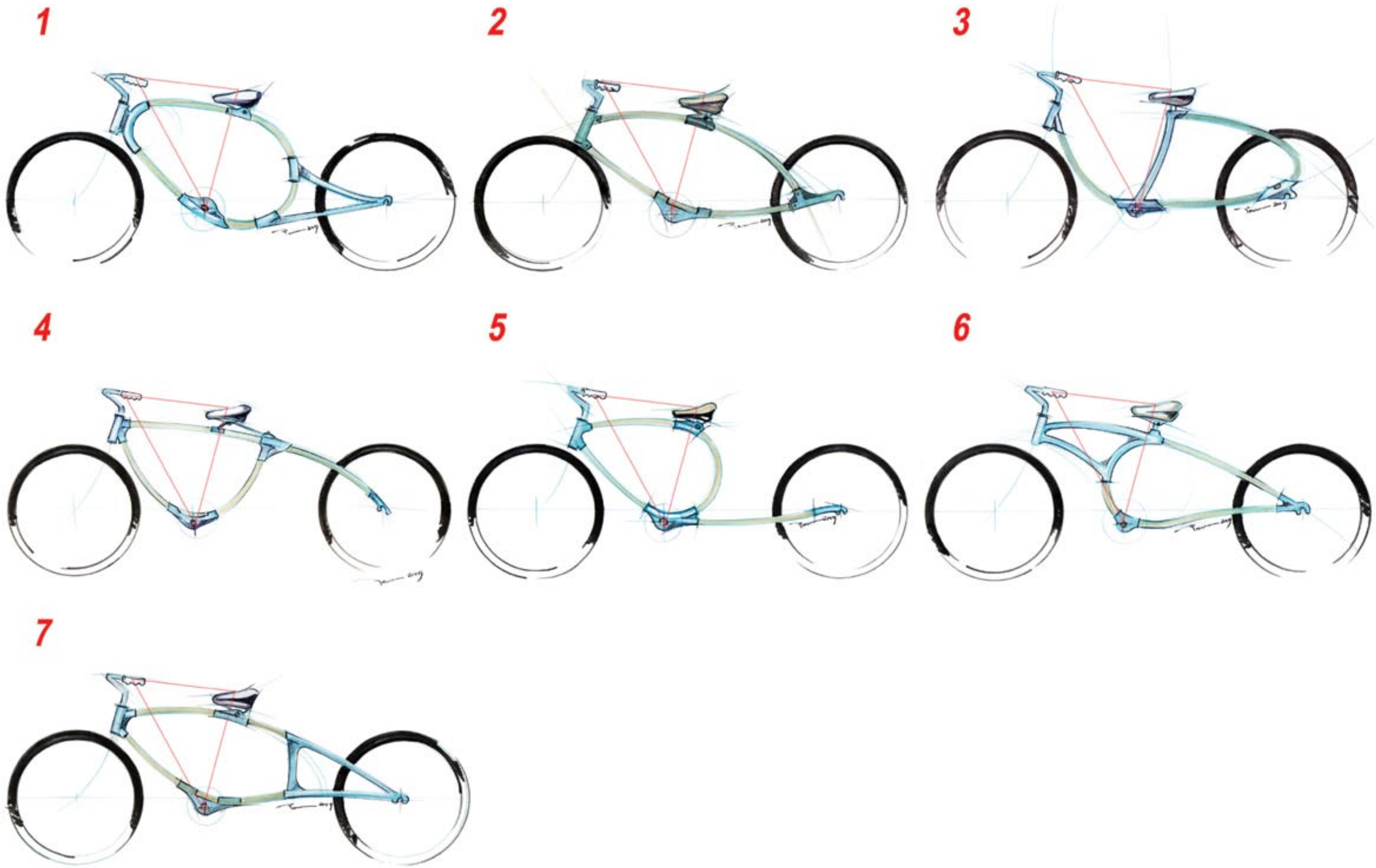


Fig 72. Seven bamboo frame concepts using old bicycle geometry

5.3.1 Design Selection

To narrow down the number of proposed design ideas further, the seven chosen sketch ideas were distributed via email to ten senior design students and forty designers from New Zealand, Australia, USA and Germany. All eighteen female and thirty-two male participants were asked to choose the design they

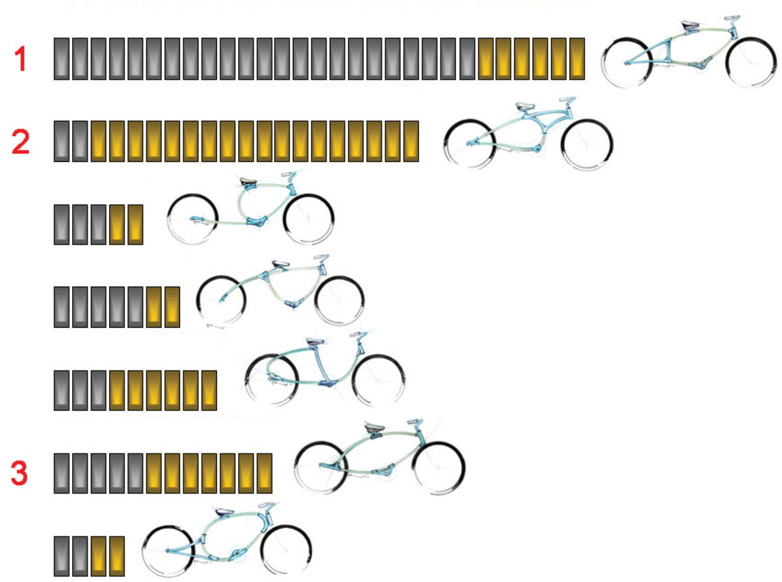


Fig 73. Table of the results of bamboo frame selection

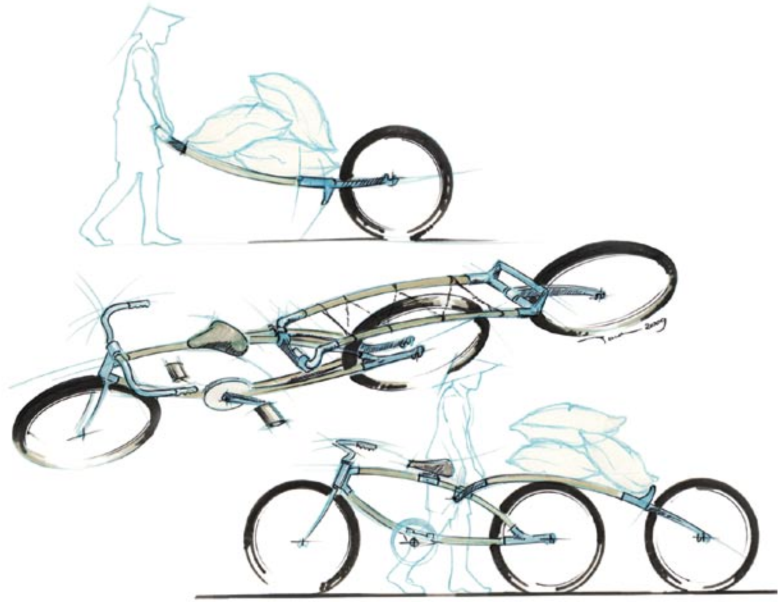


Fig 74. Chosen Design Concept no. 1

thought was the most suitable laminated bamboo frame design idea for the lower income bracket and also a second best design choice.

A table was created to illustrate the final result, using a gold bar to indicate the participants' first choice and and a silver and bronze bar for their second and third choices respectively. Results show that Design Concept #7 was chosen the most, with 29 picks, followed by Design Concept #6 with 21 picks and Design Concept #2 with 13 picks.

5.3.2 Design Opportunities

With these new frame design concepts, there is an opportunity to create a whole new system. The three most favoured new design frames can be developed further with the inclusion of an attachment system as part of the design, focusing on the functionality of the bicycle based on the needs and wants of the target user. When the top tube and seat stays are replaced by one continuous curved piece of frame, this provides for more joining point locations for a trailer and such like. This joining point also acts as a pivot, allowing the trailer to move freely from side to side when cornering which would work better. With the attaching joining point being set higher on the bicycle's top frame, as opposed to the rear wheel of the bicycle, the trailer arms would sit above the rear tyre and thus not interfere with it, unlike Trailer Design B, where the joining points are on the side of the rear wheel. The long top frame could also provide an area to hang baskets. Another advantage of this particular frame design is that laminated bamboo can be created using one mould including the one-wheel trailer arms.

Taking this idea further, a full storage unit could be created which works as a trailer and would be constructed from bamboo material. This allows for the trailer to be used with or without the bicycle. The system would be beneficial to the fruit, vegetable and food hawkers as well as the movers. This also means a second person can use the bicycle while the other can conduct their daily trading at the market. The space between the two trailer arms can be utilized and used as a serving area as shown in the next concept sketch.

The next idea is to explore the functionality of the bicycle, focusing on the environment. The requirements of human powered, land based intermediate means

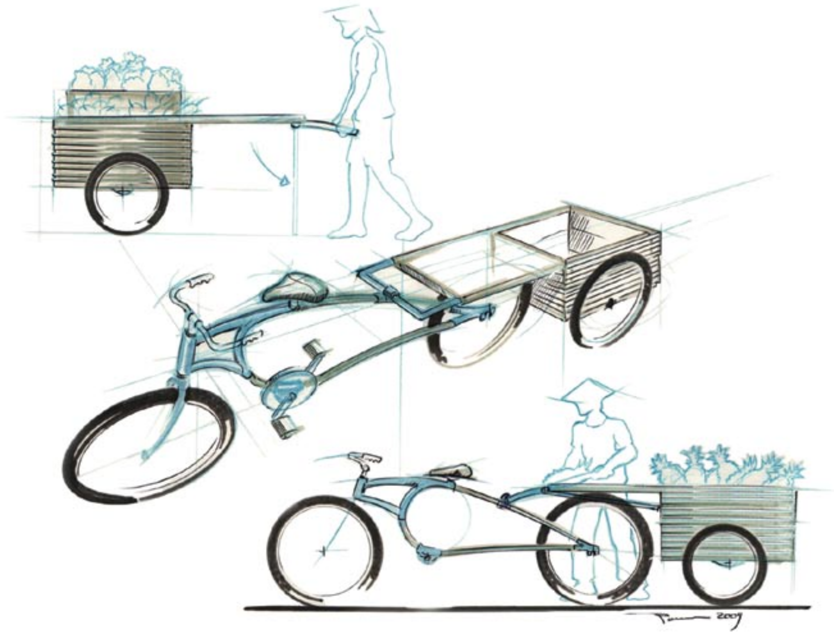


Fig 75. Chosen Design Concept no. 2

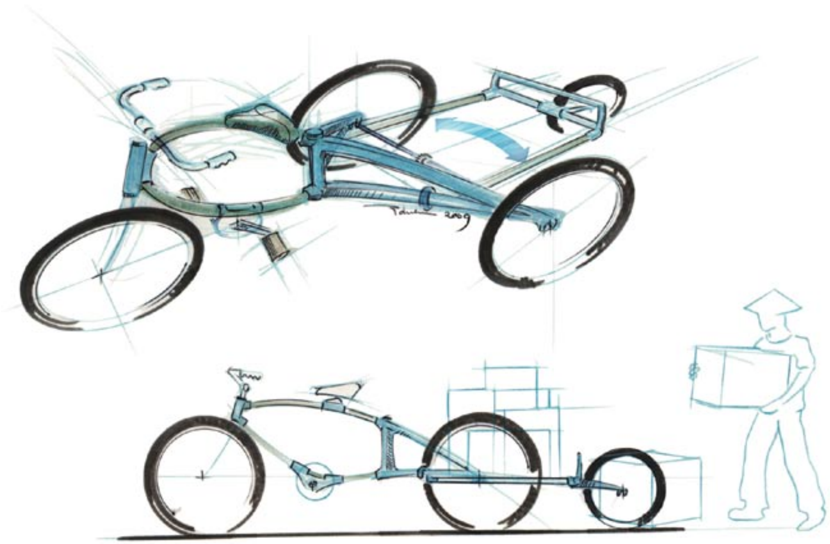


Fig 76. Chosen Design Concept no. 3

of transport in Third World countries vary between individual and commercial uses. For commercial use, it is important for the bicycle to have a larger load bearing capacity while for individual use this need is diminished. This is significant because in Third World countries there is automobile congestion on many streets and the bicycle still needs to be able to negotiate gridlocked street traffic. Perhaps the bicycle's storage capabilities could be added to by increasing usable space by unfolding parts when needed, or folding up and packing away parts when not carrying any load, or otherwise taking up as little space as possible. An extra wheel could also be added to increase the load bearing capacity even more. This would provide the user with more desired storage space options.

5.4 Bamboo Frame

An experiment was conducted as a follow-up exploration to see if bamboo could be used as the main frame of the bicycle, which has never been tried before. The aim of this experiment is to utilize all the positive aspects of bamboo as a material, using local skills and a relatively low technology manufacturing processes.

Instead of using bamboo poles, this experiment used bamboo strips. This decision was made after the researcher's observation visits to several local Indonesian bamboo craft workshops. Bamboo poles are used mostly for architectural purposes and furniture making while bamboo strips are commonly used for other products as they are flexible, easily processed and formed.

The local villagers who work as bamboo farmers supply dried bamboo poles to the bamboo workshop or local craftsman who then cut and split the poles into thin strips ready to be woven into products like "bilik" (wall panels), baskets, lamp shades, etc. Bamboo strips are not commonly sold as a raw

Fig77

Fig78

Fig79

Fig77-79. Local artisans slicing bamboo poles into thin strips before making baskets

product/material as it is a common practice for each workshop to produce their own bamboo strips (it is quite easily done). After talking to a local craft businessman, he agreed to supply bamboo strips for 1000 rupiah each (NZ15 cents). Each bamboo strip measures about 2m long as all the bamboo poles supplied by the villagers are in 2m lengths. Widths vary depending of the type of bamboo used, but commonly a strip is 3-5cm wide. It is possible to produce wider strips from larger bamboo species.

5.4.1 Laminated Bamboo

A laminating process was used to create the form for the bicycle frame as this is a relatively easy, economical and low technology process. Bamboo strips were cut roughly into identical widths then laid on top of each other with glue in between the layers, while a mould was used to create the form. A wooden mould is normally used for the laminating process to make the cost economical.

Fig 80. Two-piece steel mould

Fig 81. Bamboo strips on two-piece steel mould

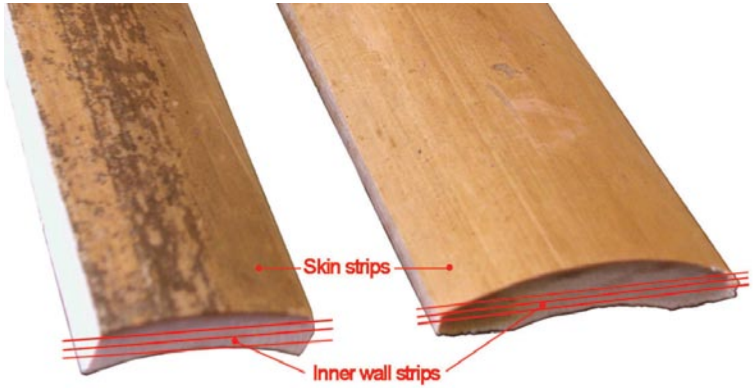


Fig 82. Image showing the strip cutting diagram from a bamboo pole

However, for this experiment a special two-piece steel mould was fabricated so it could be used over again for further experiments in the future.

A water based all-purpose white wood glue called "Lem Fox" (PVAc) was chosen as glue for the experiment, despite a suggestion from a New Zealand bamboo expert to avoid water based glues as bamboo contains silica which reduces this type of glue's effectiveness. This glue decision was made because PVAc is widely used by the local craftsmen as a multi-purpose glue in the craft industry. The glue laminated bamboo strips were stacked together in the mould which was then compressed between two pieces of steel mould and left for 48 hours to dry. The first laminated bamboo experiment produced an unsatisfactory result.

The laminated piece had uneven gaps and had parted between the layers. This result was due to using bamboo strip skin (from the outer layer of the bamboo pole). These strips retain their natural colour and skin texture finish which makes them visually more attractive; however they also retains their natural curvature and uneven surface of the nodes which prevents good surface contact when each layer is laminated resulting in the layers failing to bond.

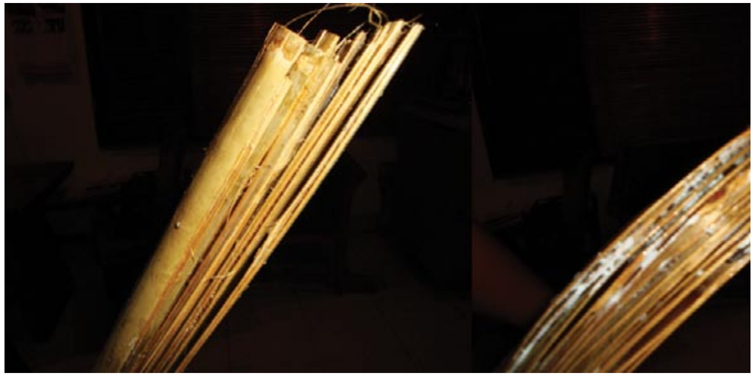


Fig 83. The first result of the laminated bamboo trial

The whole process was repeated in a second trial using bamboo strips that came from the inner wall of the bamboo pole and this produced a much better result. A strip sliced from the inner bamboo wall has a more consistent thicknesses and even surface which provides for better glue adhesion to the contact surface. The PVAc glue seemed to work perfectly however further tests still need to be conducted over a longer time period under the local harsh weather conditions to ensure its effectiveness.

5.4.2 Finishing

The laminated bamboo pieces seemed to spark lots of interest and intrigue among the local craftsmen. Positive feedback was given by the locals who thought the idea of laminating bamboo strips was a great idea and it was new to them. They also suggested a better glue to use called “Daibond”, a two-pot epoxy glue which is commonly used by local furniture makers instead of the water based “Lem Fox” (PVAc). However, after further investigation and trials with the two glue types, the water-based glue PVAc was considered superior because:

1. It is a water based product which is environmentally friendlier and contains fewer toxins compared to epoxy glue which is harmful to the environment and users (with irreversible effects). (Ameron, 2008)

2. PVAc has a slower curing time (24 to 48 hours) and this allows for time to adjust the bamboo strip

Fig 84. Bamboo strips measured to the required size

Fig 85. Bamboo strips cut to the required size

Fig 86. Bamboo strips sanded and shaved to size

Fig 87. The finished product

layer positioning and to correct any mistakes in the process.

3. Epoxy glue is much more complex to use, requiring a strict mixing recipe to be followed. It has a faster curing agent and therefore the whole laminating process needs to be done in a relatively short time with very small margins for error. A small mistake can be costly as materials exposed to epoxy cannot be reused or recycled and needs to be discarded.

4. PVAc creates a more flexible bond and rubbery finished layer of film when dried (The ChemQuest Group Inc., 2010), as opposed to epoxy glue which produces a much harder bond and creates a glassy finished residue which cracks and crumbles under heavy pressure.

5. PVAc is very economical in price, has no expiry date and can be kept for long time periods when stored in ideal conditions.

6. While finishing these bamboo laminated pieces, it was observed that when removing the excess glue from its surface, it became "hairy" from the natural bamboo fibres and splinters. Therefore a water-based paint was used to cover and seal the surface and this also improved its weather and water resistance.

Fig 88

Figs. 88-89. Before and After the water base sealer was applied

5.4.3 Bamboo Frame Construction

Two sets of laminated bamboo pieces were produced using the same steel mould for this experimental bamboo frame construction. These laminated bamboo pieces were used to build two different bicycle frames which were constructed by two different local wood craftsmen and two different blacksmiths. This experiment was done to test the skills and capabilities of the local craftsmen and to see what standard of workmanship they could produce. This provided important insights into the local craftsmen's capabilities and limitations which were used during the ideation process for the future design idea.

Taking into consideration the limitation of local skills, recycled parts were used in this construction. This included more complex bicycle parts such as the head and pedal tubes which otherwise would need to be manufactured using high technology. These bicycle parts can be easily found in local secondhand or flea markets because in most Third World countries the people's lifestyle revolves around recycling materials. (Furedy, 1990) Two incomplete bicycle frames were purchased from a local second-hand market for 100.000 rupiah (NZ$17) to obtain the needed parts for these bamboo frame experiments.

Fig 90. Bicycle parts purchased from the secondhand market

5.4.3.1 Bamboo Frame no.1

The first set of laminated bamboo pieces was used in the construction of a bicycle frame based on the traditional diamond configuration. Existing mountain bike dimension geometry was used as the basis for construction. This experiment was simply to explore the possibility of using laminated bamboo as a substitute material for steel. A local craftsman cut the laminated bamboo strips to the right length, shape and thickness needed to build a traditional diamond framed bicycle. Steel parts were used at the joining points; with some of these parts being made up from recycled bicycle parts purchased from the local second hand market.

Fig 91

Fig 92

Fig 93

Fig 94

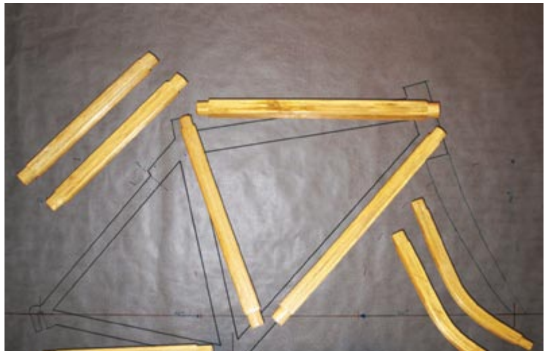


Fig 95

Fig 96

Fig 91-96. Construction processes of bamboo laminated frame no.1

Fig 97. Complete bamboo laminated frame no.1

Fig 98. Bamboo laminated frame components no.1

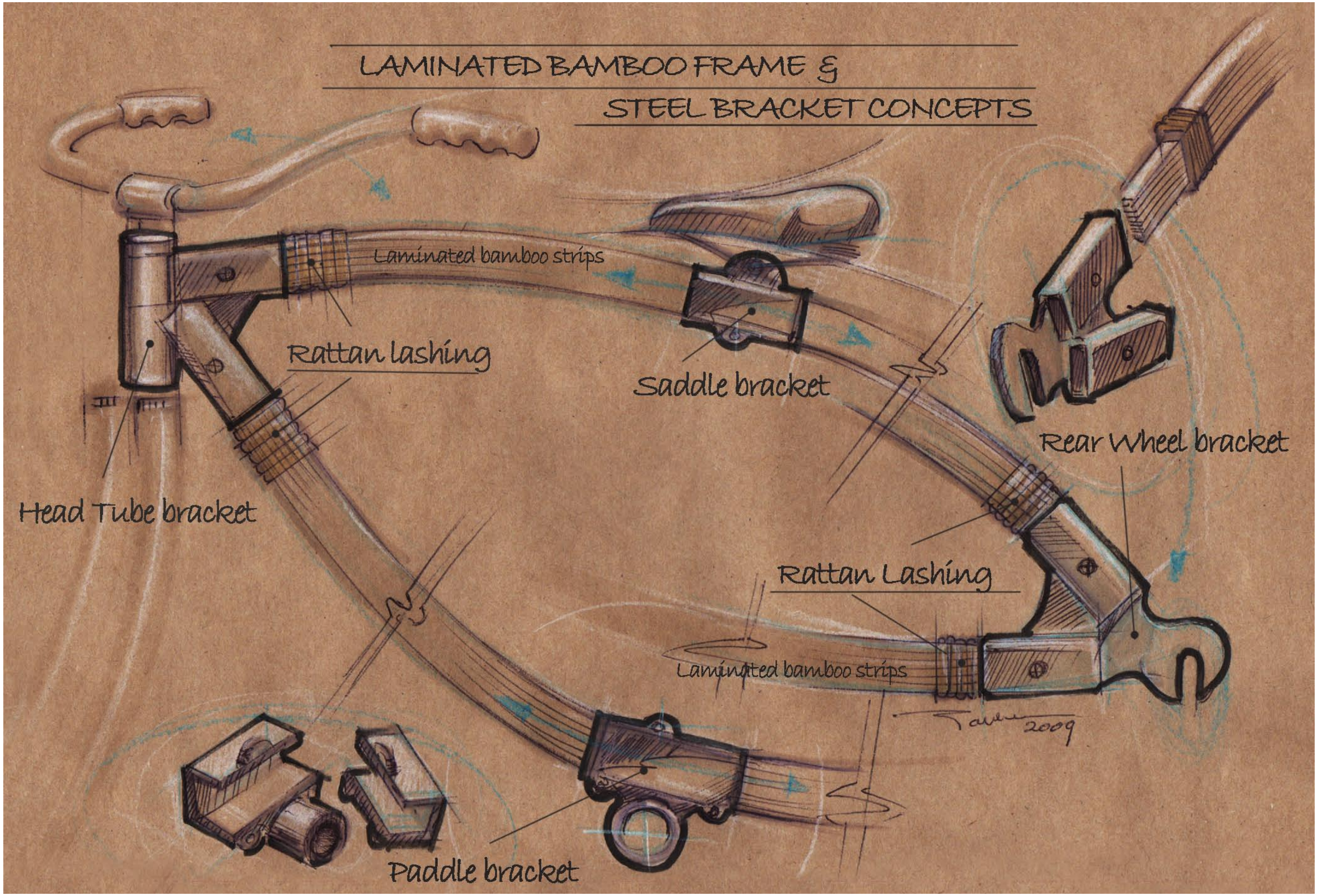


Fig 99. Proposed bamboo laminated construction no.2

5.4.3.2 Bamboo Frame no.2

The second set of laminated bamboo pieces was used to implement one of the bamboo frame concepts to illustrate the use of laminated bamboo as a new bicycle frame material. Two identically curved pieces were placed in opposite directions and joined by a simple steel bracket. The steel brackets were designed and fabricated by a local blacksmith using readily available existing steel tube and recycled bicycle parts to reduce labour and material costs. The existing bicycle geometry was used in positioning the steel brackets. Rattan lashing, commonly used in bamboo furniture joinery, was used to bind the ends of each laminated bamboo piece. This acted as a secondary binding method to reinforce the laminated layers and to prevent them from splitting due to vibration and friction caused by the steel bracket.

The outcome of the two experiments using laminated bamboo frame construction methods proved positive. However, the design only provides for the experimental exploration into bamboo use as a sustainable and economical material, while utilizing local craftsmen's skills and technology as a production process but does not address the operational side of the bicycle's design. This was explored in the next stage using the most recent technology on mass production manufacturing processes, information gathered from the research methods, material testing and insights gathered from the visit to Indonesia while also focusing on the needs, wants and affordability of the target users in Third World countries.


Fig 100.


Fig 101.


Fig 102.


Fig 103.


Fig 104.


Fig 105.


Fig 106.

Figs 100.-106. Construction processes of bamboo laminated frame no.2

Fig 107. Complete bamboo laminated frame no.2

Fig 108. Bamboo laminated frame components no.2

5.5 Greencycle

High technology has the connotation of high cost and is normally associated with sophisticated products. With this final proposed design idea, high technology was introduced to explore the possibility of simplifying the process and minimizing the labour and production costs while still focusing on improving the human powered functionality, accounting for the needs, wants, desirability and affordability of the target users and the use of appropriate technologies with environmental considerations. Based on the information and insights gathered from earlier research methods, the following changes have been made to the Greencycle:

5.5.1 Frame Length Increased by 20%

This allows for more surface area to carry loads without compromising the stability, manoeuverability and safety of the user. This decision was made based on the prototype user testing of the bicycle extension done in Kerawang.

5.5.2 Attachment Points

Providing an attachment point designed specifically to accommodate other attachment systems will increase the function of the bicycle from not only being a people mover but also a goods carrier. This was realized from findings during the observation stage where the lack of an attachment point became clear. To have a versatile attachment system will give

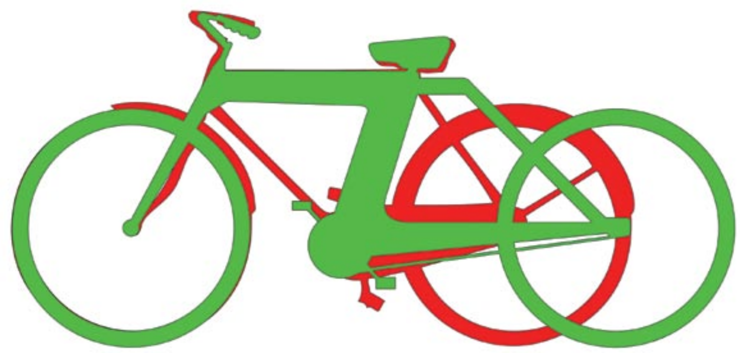


Fig 109. Frame length comparison between the Greencycle and the traditional pre-1970 bicycle

the target user freedom to develop or customize their bicycle and turn this humble people mover into a form of transportation which better suits their needs and wants without compromising its functionality as a form of transportation and operational safety.

Changing the shape of the downward angled seat stays of the traditional bicycle created an opportunity to provide not only a support for the rear seat but the point of attachment needed for the first eleven proposed design ideas and any new attachment design options as shown in the next Figure. These new ideas are about creating a new framework so the bike can have a passenger seat while using a

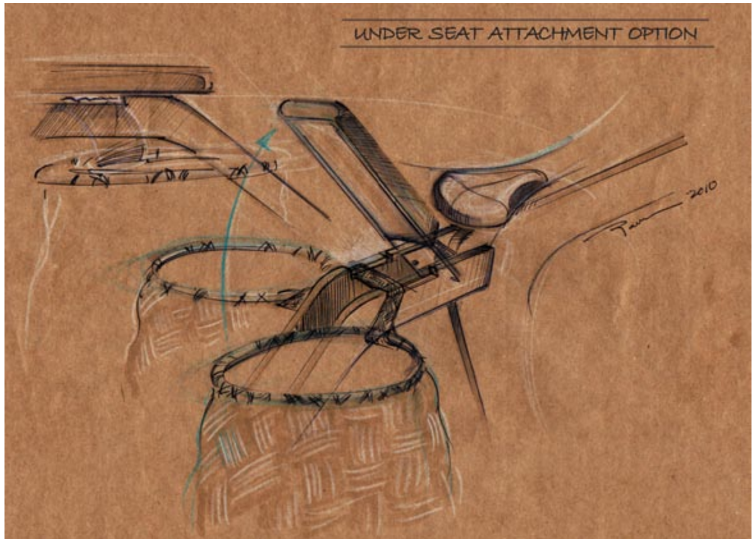


Fig 110.

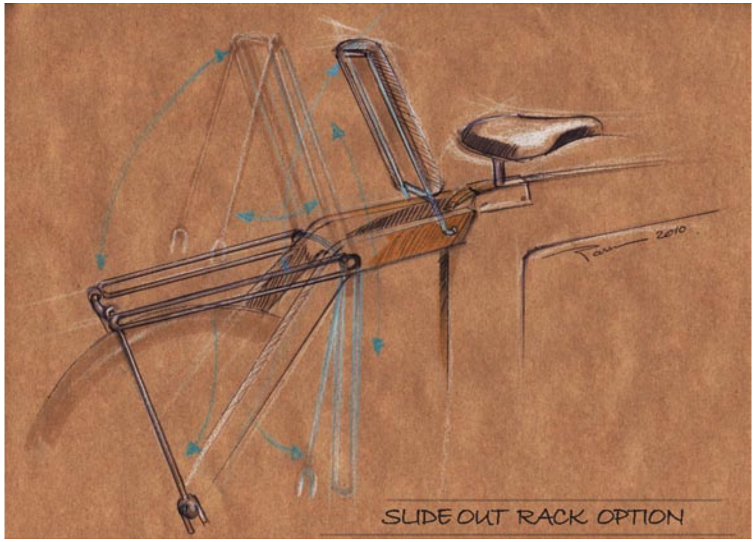


Fig 111.

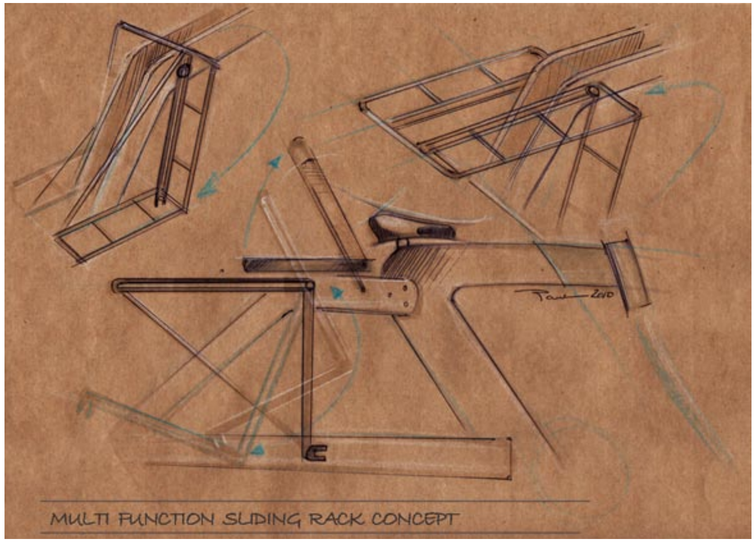


Fig 112.

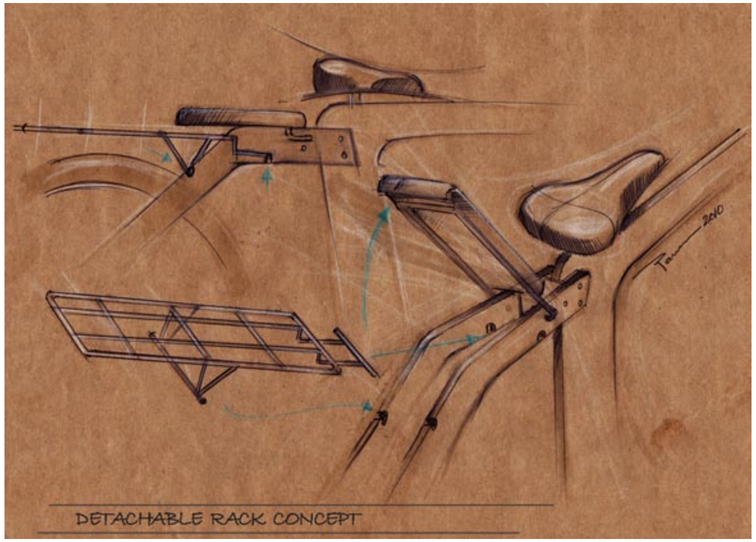


Fig 113.

Figs. 110-113. Concept sketch showing other attachment opportunities steel rack to carry rear loads. The seat can be lifted up when each steel rack is put to use, then dropped down to lock/secure the steel rack in place. The bicycle then has the dual function of being a people and goods carrier at the same time. This new idea was supported by the feedback from the bicycle and motorcycle taxi owners in Kerawang who indicated a genuine need for an attachment that could carry loads as well as people.

Fig 114. CAD rendition of attachment point options on the Greencycle

5.5.2.1 Mock-ups of the new frame.

A series of semi-working scale mock-ups were built to explore the mechanical flow of each idea and to see how each idea could be integrated into the Greencycle's proposed design frame.

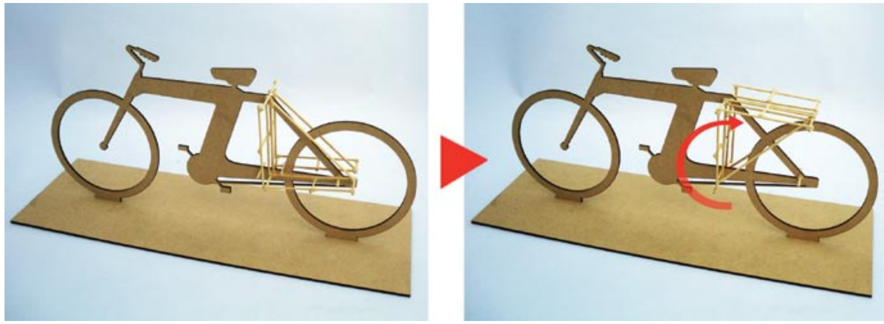


Fig 115.

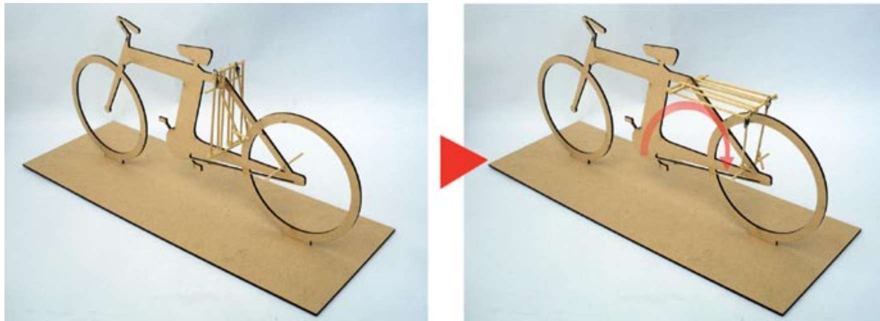


Fig 116.

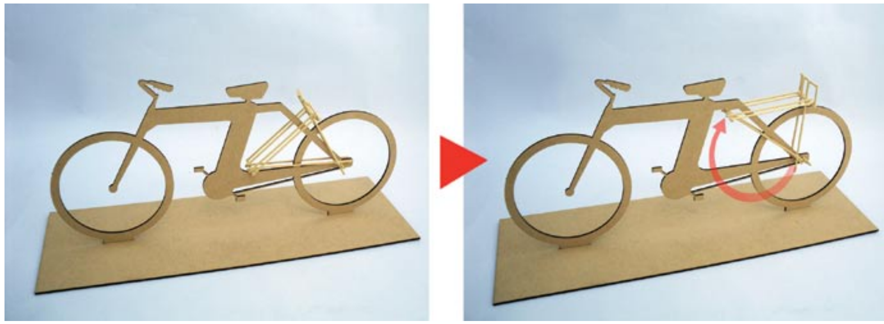


Fig 117.

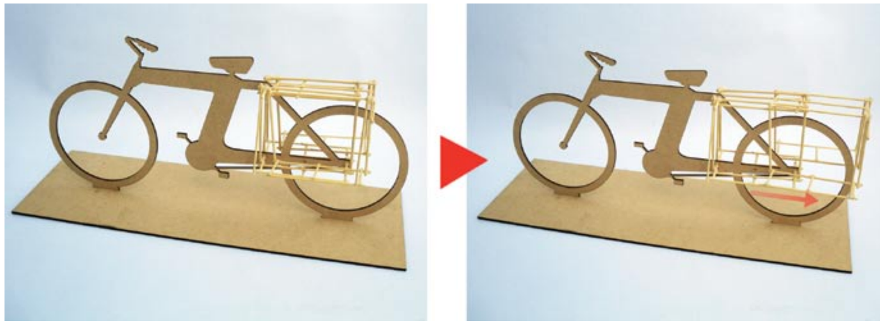


Fig 118.

Figs 115.-118. Four mock-ups to illustrate Greencycle attachment options

5.5.2.2 Extra attachment points.

By eliminating the down tube, this created room for an attachment under the top tube. Two slots were cut out of the top frame panel to allow for attachment under the top frame, as illustrated in the next diagram.

Fig 119. How slots can be used for basket attachment

5.5.3 Bamboo Panel Product

Pre-fabricated materials have been chosen for this final concept design. There are many types of bamboo based panel product available on the market which has been developed in Asia (the first bamboo panel was made in China during World War I. These bamboo panel products have been proven to be suitable for structural as well as non-structural applications in high grade building work. These applications include floors, walls, doors, ceilings and roofs and due to their superior natural rigidity and enhanced durability (through preservative treatment), they offer significant advantages over using it in its natural state. (Xiao, et al., 2008) The quality of these bamboo based panel products has not been explored as a construction material for human powered transportation such as the bicycle, however with the increasing demand for using greener and more highly renewable materials followed by recent technology developed in India and China, research studies and material testing has shown positive results for quality and mechanical strength.

Using pre-fabricated bamboo panel product offers a number of advantages including:

1. The product is made from a renewable material, abundantly grown and commonly available in Asian countries where it is commercially developed and produced (Ganapathy, et al., 1998) and this is where the Greencycle concept idea will be implemented. Thus it guarantees the availability of material while reducing its cost and carbon footprint.

2. Control over material durability to provide consistent quality. (Hidalgo, 1992)
3. Standardized dimensions and properties. (Xiao, et al., 2008)
4. Various dimensions and thicknesses are available on the market which provides cost options for target users. However, it needs to be made clear that this cost option may affect the longevity and quality of the final product. However, having this option gives the low income bracket user a better chance to purchase and own this land based, human powered intermediate means of transportation until they have sufficient funds to purchase a better form of transportation.
5. Since many parts are made of paneling product, the whole bicycle can fit into a small flat-pack package making it economical to transport (reducing carbon footprint) if shipping is required.

However, it needs to be noted that some of these bamboo based panel products do require some additional sealing to increase product life and protect them from environmental conditions. Environmentally friendly sealant products such as linseed oil or bees wax can be used.

Fig 120. The three basic forms of Greencycle components

5.5.4 Design Pattern

The Greencycle has been designed to reduce the number of component parts in consideration to production costs. Three different forms with two sets of identical parts were repeatedly cut out from a bamboo based panel product.

5.5.5 CNC Router (Computational Numerical Control)

Each part was cut out of a 20mm thick bamboo panel product using a CNC cutter; not only to get consistent form and precision positioning of the screw holes but to also maximize the material use and minimize material waste in the process. Each bamboo panel comes in sheet form measuring 1200 x 2400mm and enough parts for eight bicycle frames can be cut out in a short amount of time.

However, the first basic form in Fig 116 is not common in mass production methods, which cut out an identical pattern on each panel in relation to the grain direction of the panel to produce the strength required for each part, therefore maximizing material use. So in this case, technology will help reduce the production cost of the Greencycle quite considerably.

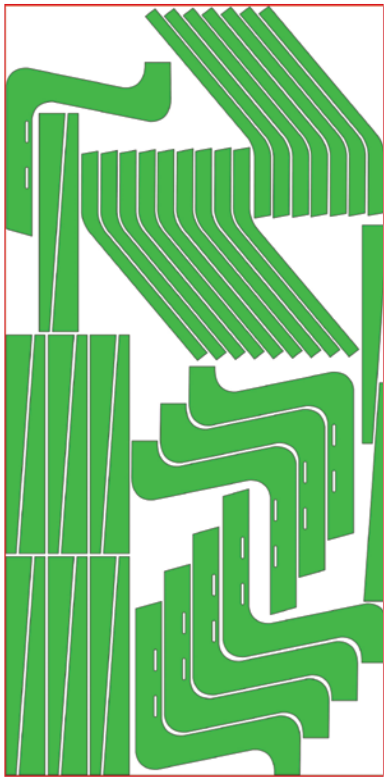


Fig 121. Cutting diagram showing the number of bicycle parts that can beproduced out of a 1200 x 2400mm bamboo based panel

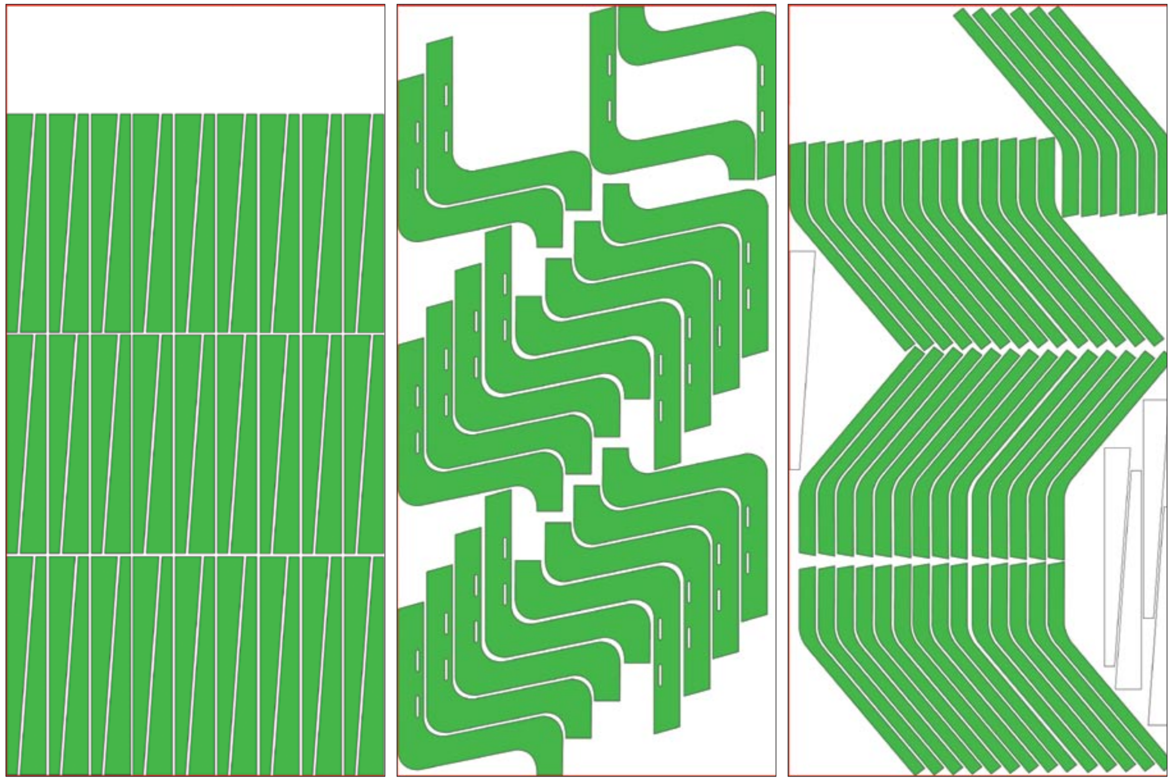


Fig 122. Cutting diagram showing identical parts cut out on individual panels

5.5.6 Steel Brackets

The steel brackets were created from flat steel and used as a joining component. The decision was made based on insights gathered from literature reviews regarding earlier bamboo frame construction (Calfee, 2009; Meres, 2004) which highlighted the importance of having a strong joining point to ensure the structural integrity and safety of the bicycle while keeping it economical and friendly to the environment. The thinking behind using steel brackets is to have strong brackets which will last and can be reused again while the bamboo parts can be easily and cheaply replaced when needed.

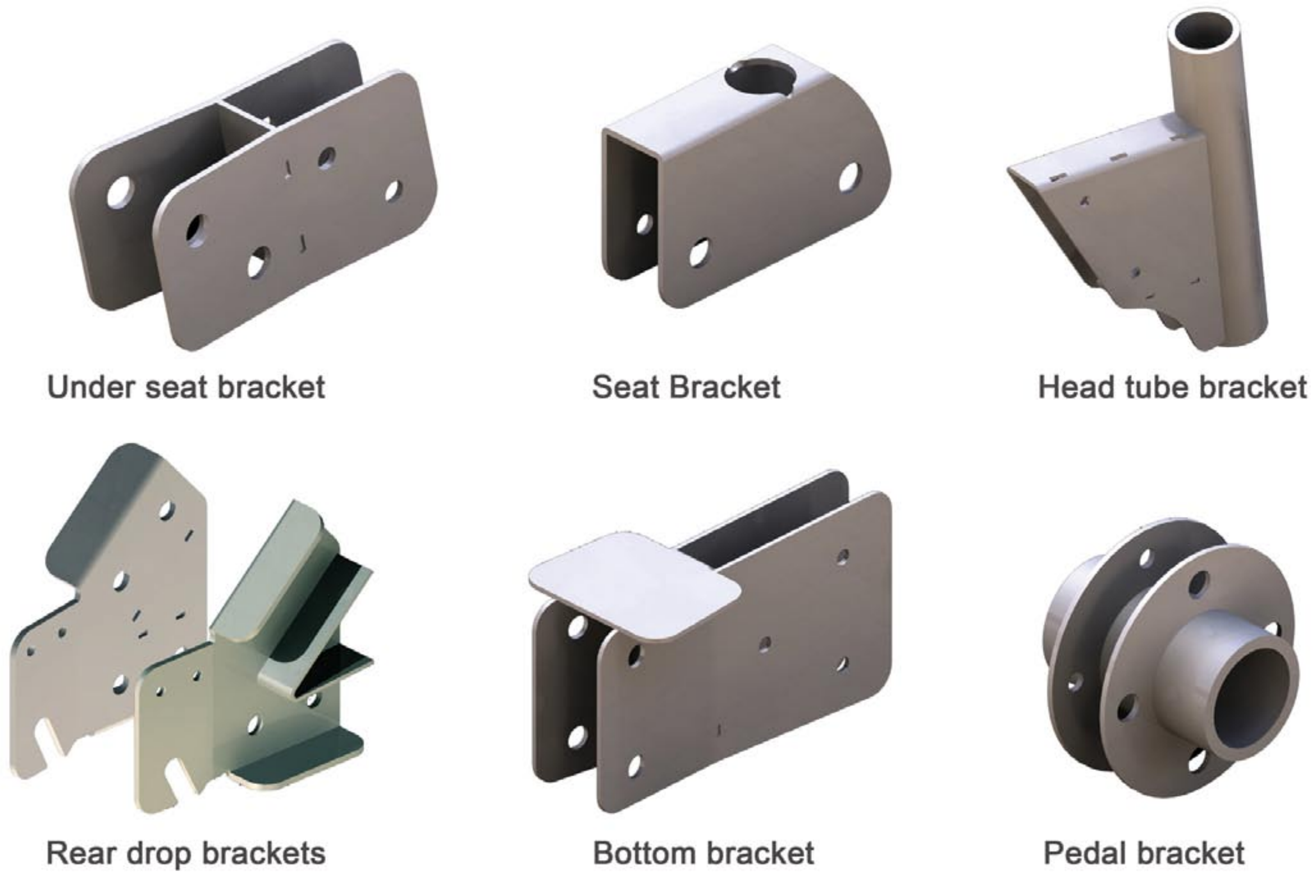


Fig 123. CAD rendition of Greencycle steel brackets

There is also the option to utilize recycled parts that are easily found at secondhand markets. This was realized in the building process of the two laminated bamboo prototypes. This may not have a major impact on saving the environment but in a small way will contribute to reducing landfill and reduce the demand for raw materials and the cost of its processing and shipment.

5.5.7 Bike Geometry

A great deal of research and ergonomic study has gone into the modern mountain bike's design and construction which has been proven to be very strong and can negotiate rough terrain easily. For this reason, the modern mountain bike's geometry has been used as the basis for the Greencycle.

5.5.8 Big Wheels

Twenty-eight inch tyre rims have been used on the Greencycle. This decision was made based on the prototype testing in the development stage of the trailer prototype which highlighted the importance of having strong wheels to function as a work horse.

5.5.9 Personalization

Early observations in Indonesia showed that public transportation owners have a tendency to decorate

Fig 120. A personalization option

their vehicles in bright colours and motifs to personalize them. This ranges from simple coloured geometric forms and images of local scenes to painted portraits of their loved ones. The Greencycle's bamboo based panel frame will provide the target user with a blank canvas to personalize their personal transportation.

5.6 Greencycle Prototyping

A full-size working prototype was designed, constructed and tested as the final design. This process was necessary to evaluate and analyze whether the criteria had been met from previous research findings and to establish any changes or modifications that need to be implemented to improve the final proposed design idea.

5.6.1 Form Ideation

A series of sketches was produced to find the most favourable form for the Greencycle frame. Form consideration included the frame's being cut out of a bamboo based panel product, pattern repetition and

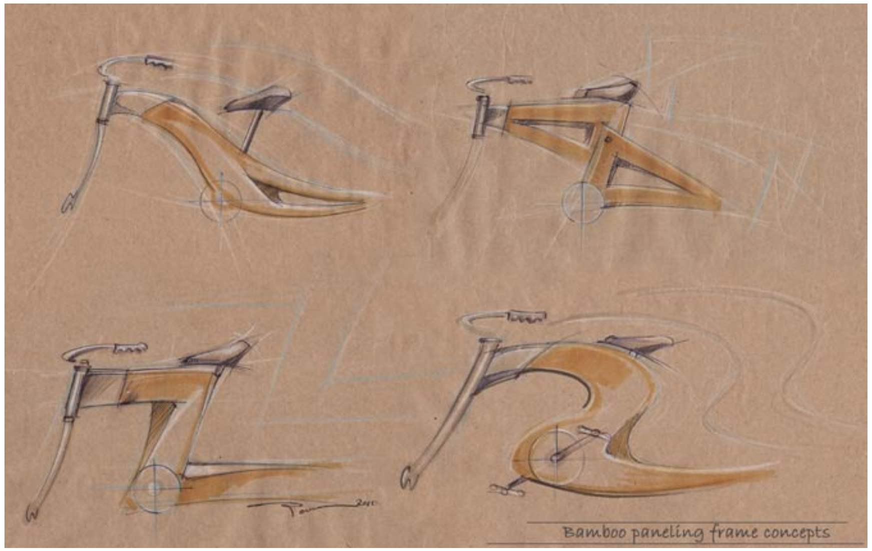


Fig 125. Concept sketches of Greencycle frame

Fig 126. Producing the full-scale Greencycle frame geometry

Fig 127. Producing the full-scale Greencycle frame pattern

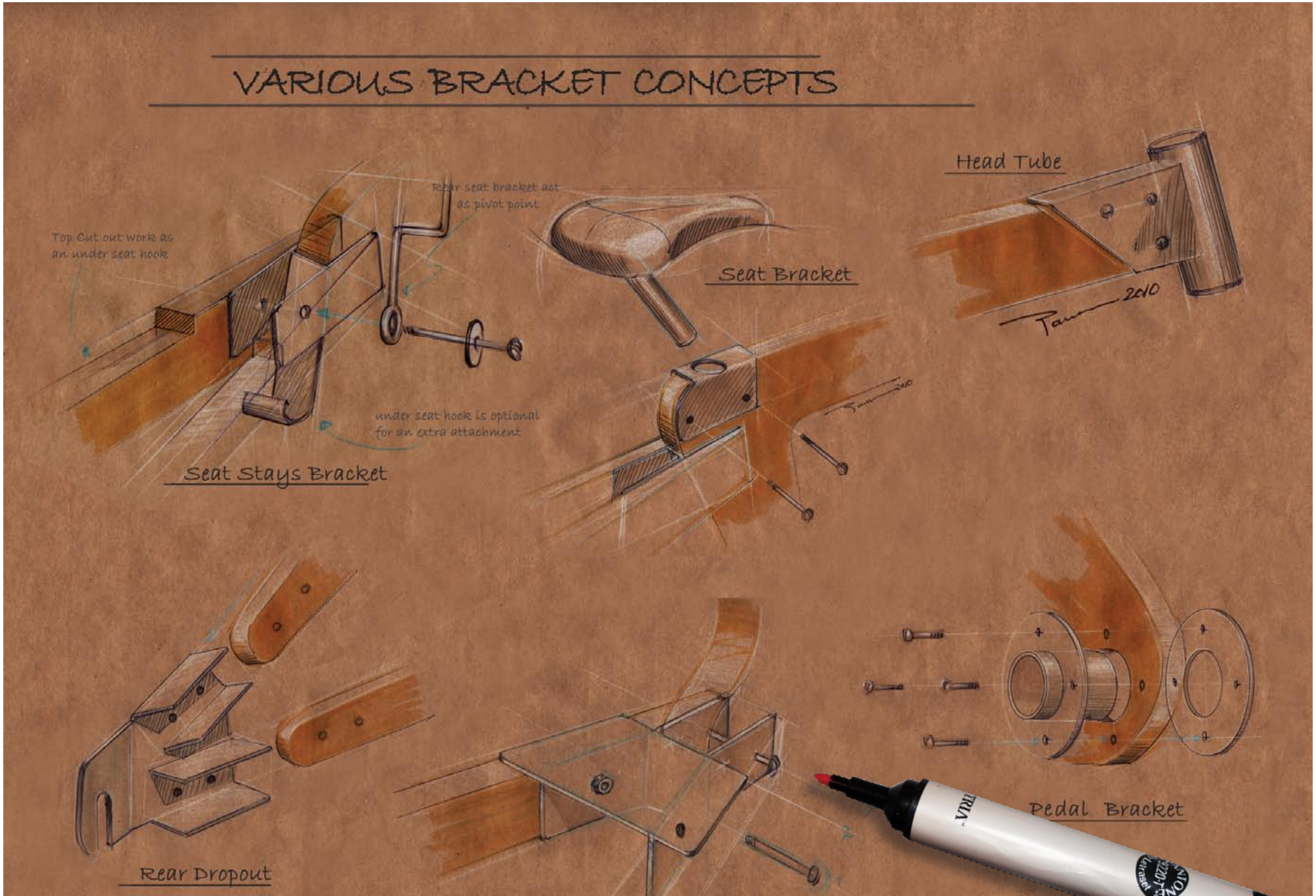


Fig 128. Concept sketches of Greencycle steel brackets

economical placement next to each other to reduce material waste.

5.6.2 Frame Geometry

The modern mountain bike was used as the basis for the geometry of the Greencycle. The selected final Greencycle pattern was laid on top of a full-size drawing of a mountain bike frame. The purpose of this was to validate the design for ergonomic and aesthetic factors and ensure manufacturability before committing to (what would ultimately be) production manufacturing.

5.6.3 Full-Scale Orthographic Drawing

Full-scale orthographic drawings were created in addition to the CAD drawing. The main reason for this was to view the design at its actual size so the proportions and profile could then be readjusted to optimize the ergonomics of the bicycle.

The other advantages for using a full-size drawing were that all measurements for the components could be easily retrieved directly from the drawing and edge profiles, screw hole locations and templates for curved and irregular parts were ready-made for part production.

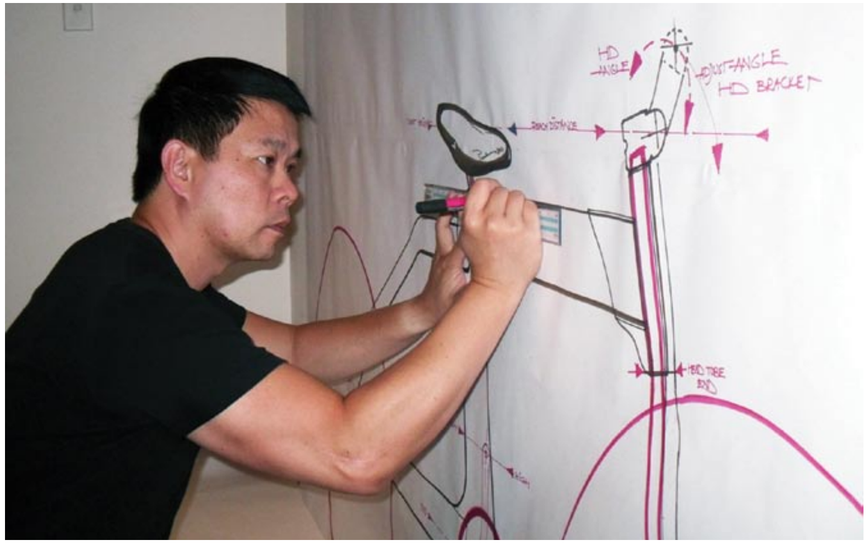


Fig 129. Full-scale drawing of the Greencycle

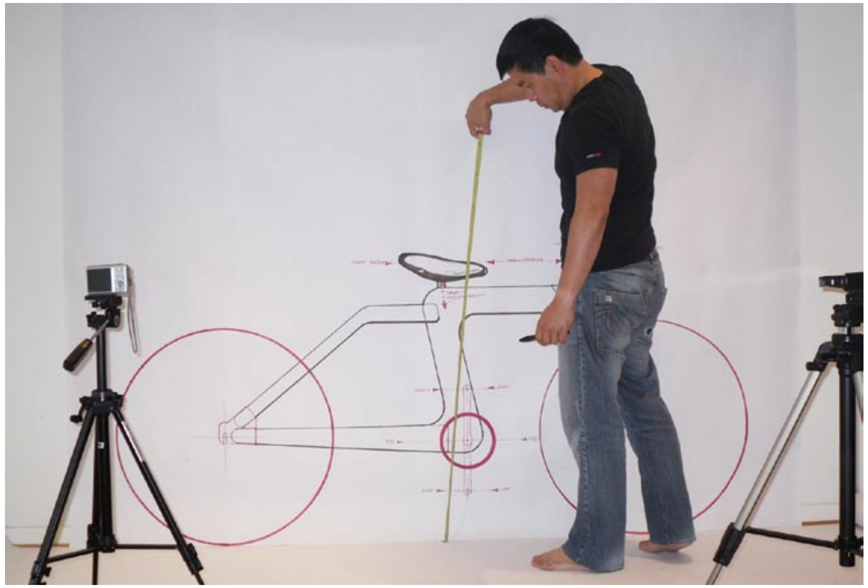


Fig 130. Dimensions can be retrieved directly

Based on research findings regarding the target group's average male height, three people were chosen and used to analyze the positioning of the rider for the proposed design. This information was then used to check the final positioning of the seat in relation to the pedals and handle bar. This is not a scientifically proven method, but due to the time constraints of this research project it worked as a framework to base the concept design on.

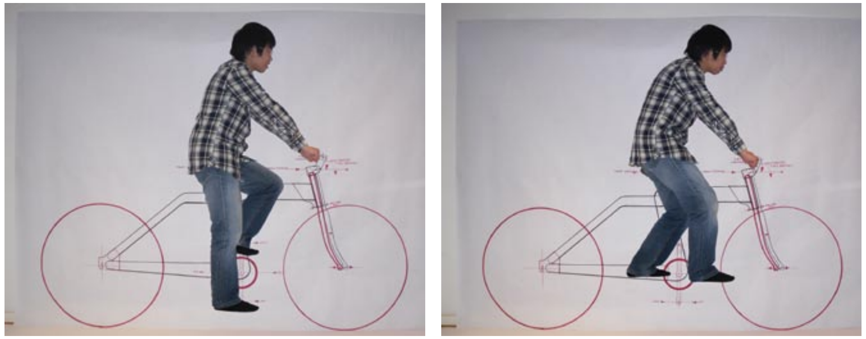


Fig 131. 160cm tall person

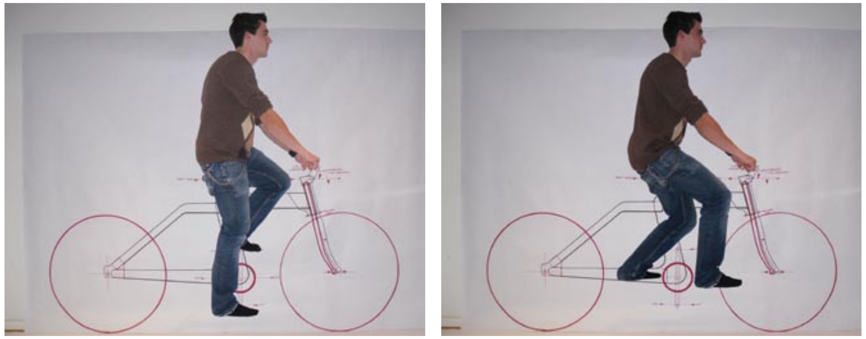


Fig 132. 168cm tall person

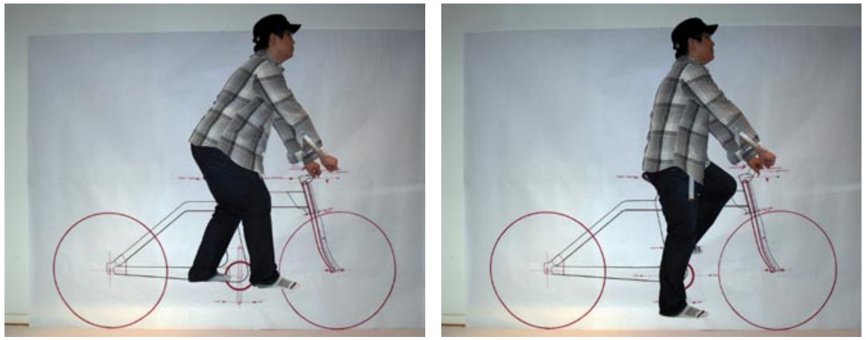


Fig 133. 170cm tall person

5.6.4 CAD – Computer Software

Computer software was used to create a virtual image of each part, which was then used to simulate the construction of the whole bicycle and view the design in 3D. This was also to ensure each part fitted and worked the way it was intended to and to detect any mistakes or changes that needed to be made to improve the design before going into production. This software generated files that were also used in the actual automated production process of each part, such as material layout for the cutting diagram, laser cutting and CNC cutter, etc.

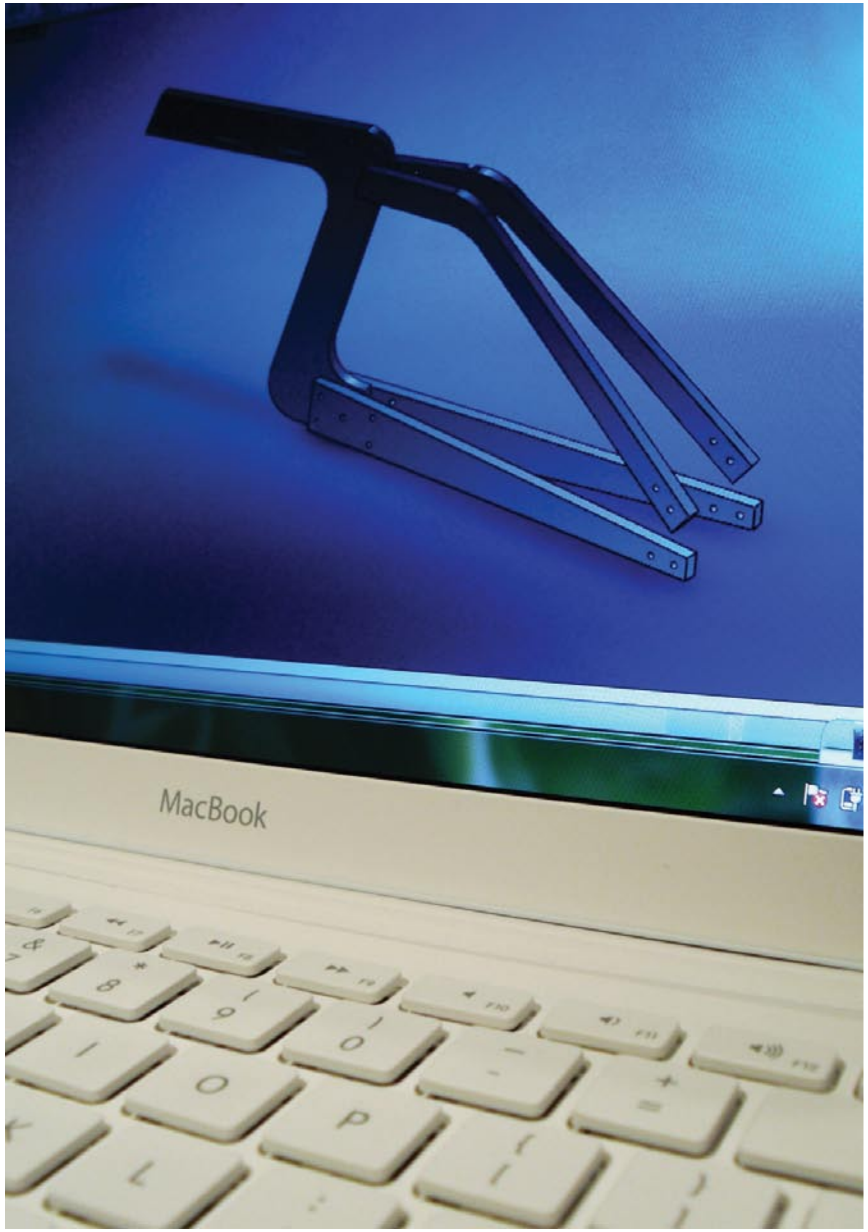


Fig 134. CAD construction of the Greencycle frame

Fig 135. CAD rendition of the Greencycle final design

Fig 136. CAD rendition of the Greencycle structural details

5.6.5 Bicycle Components

To explore the possibility of utilizing recycled materials, the local bicycle graveyards were visited to collect the necessary parts for this prototype. This applied especially to parts that would require precision manufacturing to fit in with other complex main parts such as bearings to ensure the smooth operation of the bicycle. A front fork, head and pedal tubes, handle bar and seat were salvaged from wrecked bicycles. The head and pedal tubes needed to be cut out of the frame and cleaned up. New bearings were purchased from a bicycle shop as well as the special 28 inch wheels and tyres (these were specially ordered) as they are not commonly used in New Zealand. However, the researcher's visit to Indonesia ensured the availability of this part as it is a basic requirement for bicycles used as a work horse in Asia.

Fig 137. Recycled head tube & pedal tube

Fig 138. Bicycle graveyard

5.6.6 Parts Production

Steel brackets were produced from steel plate and were laser cut to get the required shape then bent and welded together. The recycled head and pedal tubes were modified and welded to an additional steel part to fit into the final prototype frame. To fit the large wheel into the front fork, some minor modifications were made. The front fork was cut to create extra room to accommodate the oversize wheel and an

Fig 139. Modification of the front fork

Fig 140. 28 inch wheel

extra steel plate was welded to reinforce the fork to ensure its structural integrity.

5.6.7 Construction Process

For presentation purposes, JCB bolts with flat heads were used in the construction to give a flush finish on both sides. However, any other conventional bolt or screws would work just as well, with no risk of compromising the operation of the Greencycle.

Fig 141. JCB bolt flathead

Figs 142.-148. Greencycle construction process

Fig 142.

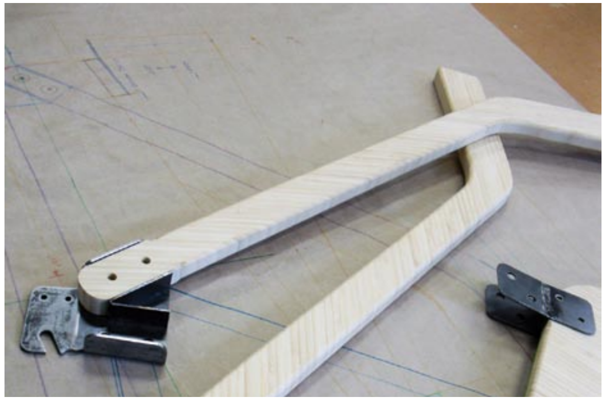


Fig 143.

Fig 144.

Fig 145.

Fig 146.

Fig 147.

Fig 148.

Fig 149. Greencycle image 1

Fig 150. Greencycle image 2

Fig 151. Greencycle image 3

5.6.8 Finished Prototype

Due to time constraints, the Greencycle was built without accessories such as the rear seat and the various proposed attachment ideas. At this stage, scale mock-ups illustrating all the proposed attachment ideas had provided the target user with a sufficient understanding of what these attachments can offer and how they can be easily adapted and attached to the Greencycle.

Fig 152. Greencycle images 4-7

5.7 Extra Wheel/Trailer

Incorporating an extra wheel as a possible strategy to increase the functionality of a bicycle was mentioned at the brainstorming sessions and when interviewing the experts. The idea of using an extra wheel on human powered transportation such as a bicycle is not new. However, there is little information to be found in the literature. Observation in Indonesia revealed specific uses where an extra wheel on a bicycle could be an advantage, i.e. as a trailer on an intermediate means of transportation used in the farming sector.

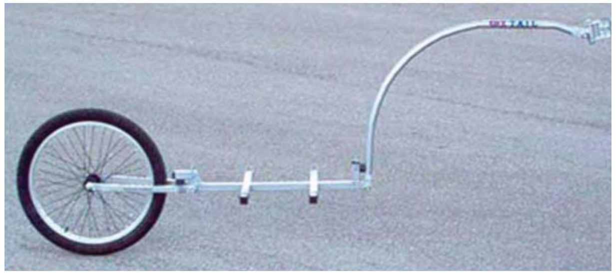


Fig 153. Extra wheel Croozer

Fig 154. Extra wheel Voyager

There are examples of smart one-wheel bicycle trailer designs for the commercial market (Oxtail Bicycle Trailers, n.d.) (Extra wheel, n.d.) (Croozer, n.d.).

Most have limited load bearing capacity and come with a high price tag which makes these commercial trailers unfavourable and inaccessible to users in the lower income bracket in Third World countries.

Consequently, consideration was given to exploring a series of ideas using an extra wheel to increase bicycle functionality focusing on the needs of target users in farming areas.

Currently the bicycle provides target users in rural farming areas with an intermediate means of transport however the means of transportation becomes less practical when required to function as a load carrier. With a load on, a bicycle's function is no different to that of a push cart. For users in the lower income bracket, time lost in not having access to proper means of transportation also means lost time for earning a living. For most rural users at this economic level, the amount of income that can be made correlates directly to the amount of time available in a day. It is fair to say that the success of the proposed design idea can be attributed to and measured by the increase in income experienced by the target user.

Creating a trailer for a bicycle seems to be a logical solution, however the extra cost of having this trailer needs to be perceived as a worthy benefit by target users for it to be accepted. Most padi farmers in rural areas leave their bicycles on the farm edge by the main road and the harvested padi

Fig 155. Farmer carrying rice seedlings for planting

Fig 156. Padi field harvest

is carried by the farmer to the bicycle (where it is left) and then loaded. This process will be repeated until the maximum bicycle load is reached.

A dual-functioning trailer that can be easily attached to a bicycle to increase its load bearing capacity and also be used as a wheel barrow that can negotiate the narrow footpaths on a padi farm and carry farm produce would be a labour and time saving asset. For the farmer, this would reduce the physical drudgery of having to carry the produce themselves, enable greater loads to be carried between the field and their mode of transport, improve their productivity, save time and raise their income potential.

This task comparison is illustrated in the following diagrams.

Fig 157. Diagram illustrating the time saving for every task eliminated when an equal amount of load applies to both scenarios

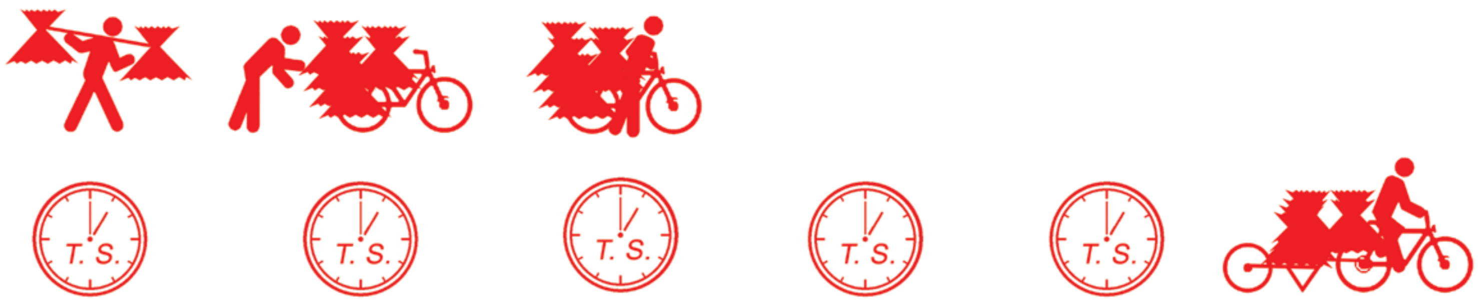


Fig 158. Diagram illustrating the time saving when more loads apply surpasses the bicycle load bearing capacity to both scenarios

The trailer idea started with a list of criteria based on previous research and design methods. This list includes:

1. A one-wheel trailer is the logical solution to negotiate the narrow footpaths weaving through the farmland and would be used as a wheel barrow.
2. Extra attention needs to be given to the joining bracket design as it plays a vital role to the functionality of the trailer.
3. By increasing the load bearing capacity, restrictions need to be incorporated into the design to make it safe for the target user.
4. The usability of the proposed design needs to be simple enough to be understood and easily operated by the target user.
5. The frame construction needs to provide possible attachment points for other storage units.
6. The frame construction needs to be safe but economical to make it viable for the target user, keeping in mind bamboo as a possible material.
7. The proposed design needs to be flexible enough so it can be adapted for other users in similar target demographics.
8. The proposed design needs to be able to accommodate different wheel sizes to enable flexibility of use and make it economical for the target user.

Hand drawn sketches of the basic frame construction were produced to explore design ideas for a suitable trailer frame and show various ways to load a variety of goods.

This basic design will allow other types of storage units to attach easily to the skeleton frame construction. By lowering the platform to the same height as the bicycle rear axle, the user will be able to attach the trailer with ease as they won't have to lift the trailer too high. Having a low platform also means having a lower centre of gravity which will improve the bicycle's stability.

Existing trailer products on the market utilize the under seat tube and rear axle as the joining point for the trailer. For rural target group users, the rear seat has given them a useful platform to carry their goods and it was decided that it was best to keep this function available. With the extra space created by the trailer, the rear seat can return to being used as a passenger carrier as originally intended. Therefore to use the under seat tube will be proscribed.

A decision was then made to explore other parts of the bicycle as a possible placement point for the joining bracket without losing the rear seat functionality. Five different concept joining system ideas were produced using scale working models to simulate the movement of each system which otherwise would be difficult to show as a 2D drawing.

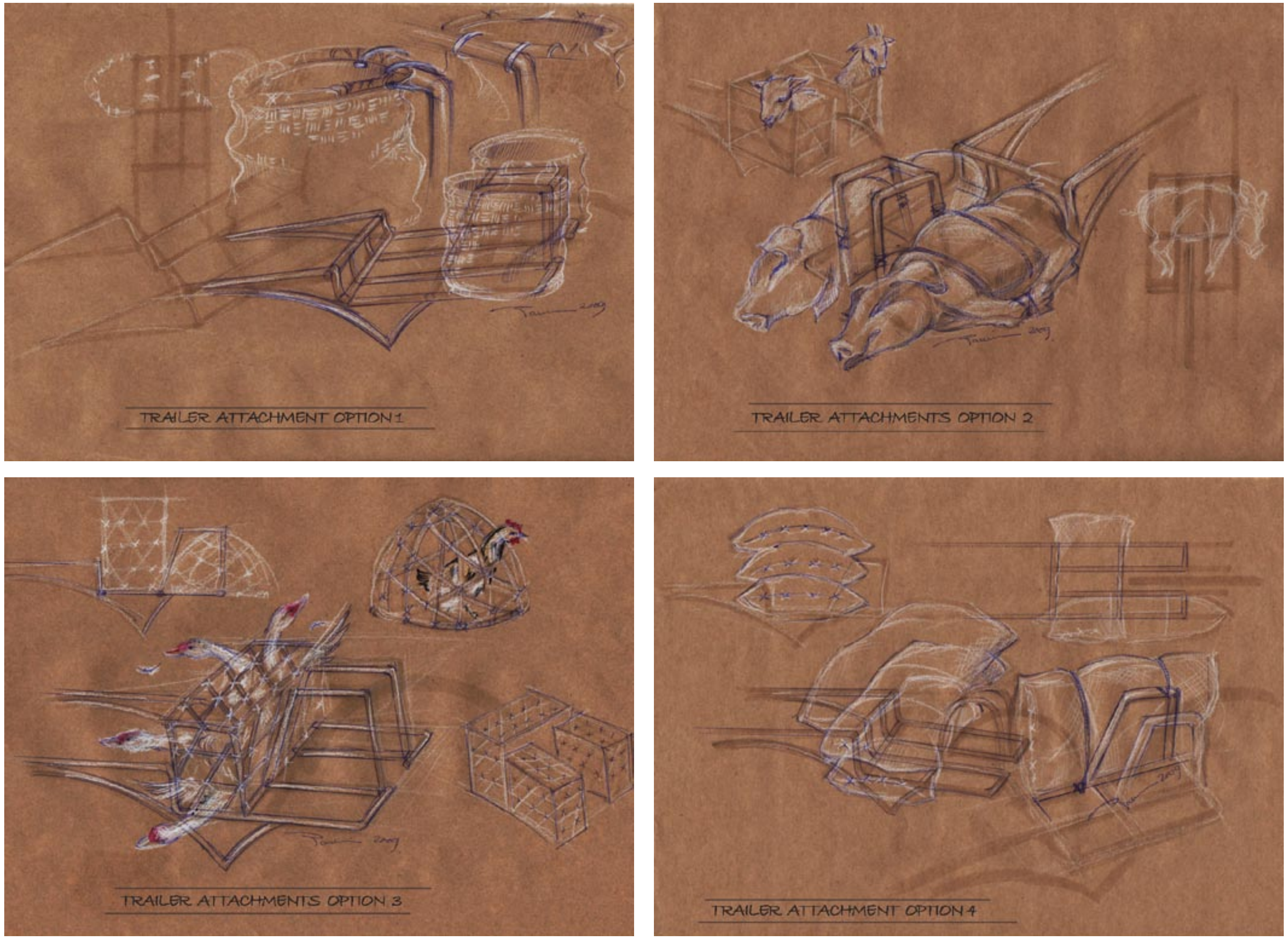


Fig 159. Four proposed loading arrangements

5.8 3D Concept Models/Mock-ups

A series of mock-ups can be built to evaluate a design idea, however it is important to first represent that idea as a prototype. This method helps encourage the designer to think three dimensionally to consider the needs and wants of the intended users, their tasks and their environment. (Jordan, 2000) Therefore usability issues can be explored at a very early stage in the design process. Understanding the scenario in which the product will be used or misused was one of the aims of the mock process.

Moreover, to understand and resolve the mechanical parts and associated issues, design idea is best explored in a three dimensional form. After thinking through these series of design sketches, it was time to build something more concrete that could be explored by designers and can also perform as a more detailed description for further work. Other details that are lost in any plain representation or in the traditional 2D presentation can be explored in detail in 3D form or by quick simple models known as mock-ups.

At this early design stage, the product might be demonstrated as a series of simple 3D mock-ups showing the functionality and mechanical flow when the product performs one of the delegated tasks. Mock-ups are "very early prototypes" constructed of simple or otherwise low fidelity materials. Mock-ups are sometimes used by designers mainly to acquire feedback from users about designs and design ideas early in the design process. A surprising amount of information can be gained by showing a simple mock-up to a few users. The mock-up may even reveal hidden misunderstandings in the design development phase. (Lewis & Rieman, 1993 & 1994)

At this stage the 3D mock-ups help an idea to be viewed in a 3D form. It is natural to better understand a concept when you can perceive depth, form and perspective. This benefits the designer through better interaction and gives a greater understanding of the mechanical flow over a simplified 2D drawing that comes with its own limitations. A 3D mock-up may not have all the functionality that will be in the final product but it has enough to test aspects of the design to help designers decide which design characteristics to keep and which to change.

In this research project the 3D mock-up enables the designer to understand all the product's working and development which in turn gives a clear, more realistic and animated concept (moving parts). In these 3D mock-ups every detail is better highlighted and this enables the designer to make changes and revisions to the product and helps the overall design stay well within the design criteria. By experimenting with 3D mock-ups, it is easy to see how the mechanism is intended to work, how the structure can be improved and how the whole

system can be integrated with existing bicycles in Third World countries. A rough measurement of the components can be calculated for extra storage. All this cannot be achieved with a series of plain 2D drawings only. For this research project the design required a simple working mechanism. Therefore the component needed to be affordable, easily replaced, remade and recycled. It also needed to be versatile so that it could be adapted for many purposes in different cultures.
(Smith, 2007)

Laser cutting was used to cut scale templates of a bicycle to produce a consistent size of template. The current existing bicycle of the target users in Indonesia was used as a reference point for these scale templates.

Simple bamboo sticks were used to represent the actual material that will be used in the final design. Bamboo sticks can be curved by bending them slowly while pouring boiling water on them. Eleven mock-up models were built to represent each idea from the ideation phase. This helped to explore the mechanical flow of each idea and to see how each idea could be integrated onto an existing bicycle in a Third World country. These mock-up models have also provided the designer with an insight into how to improve the construction and to reduce material use. These scale models were also used to explore the possibility of using different sized wheel diameters and to work out the rough dimensions of the frame.

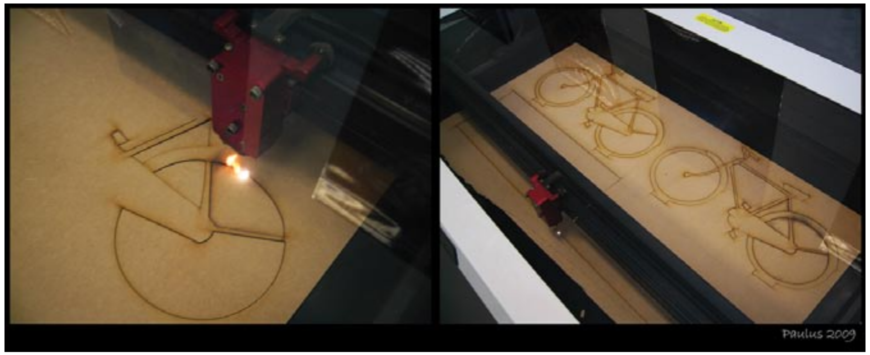


Fig 160. Laser cutting in progress

Two out of these five design ideas were chosen to be developed further. Computer generated images were used to get a more accurate illustration of the two ideas. The system needs to be simple, robust and functional. As the trailer has a secondary function as a wheel barrow, the distance between the two arms needs to be wide enough to accommodate a person’s body when used for this purpose. These arms will also act as joining points to the bicycle which allows the trailer to move from side to side when cornering. However, this movement needs to be limited to prevent the trailer arms from making contact with the rear tyre.

For each one-wheel trailer and joining bracket idea, a computer aided design (CAD) image was generated using data and information gathered from previous design processes to give a more realistic representation to the developing design idea.

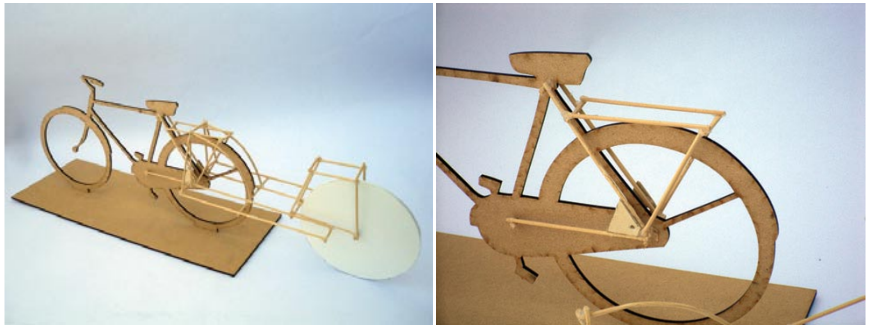


Fig 161.

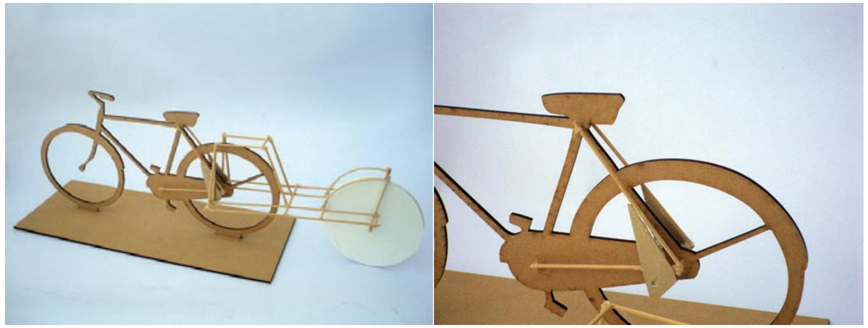


Fig 162.

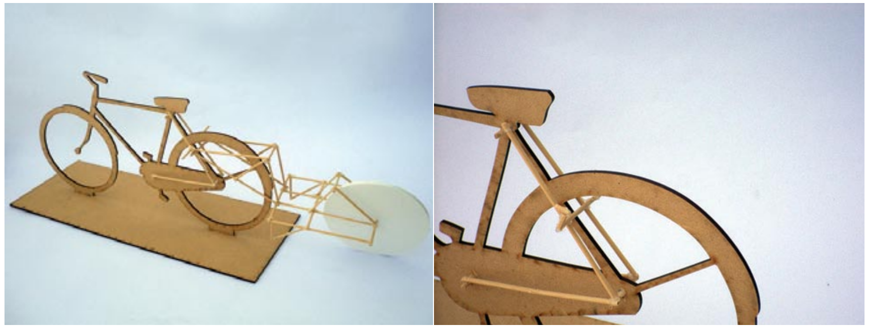


Fig 163.

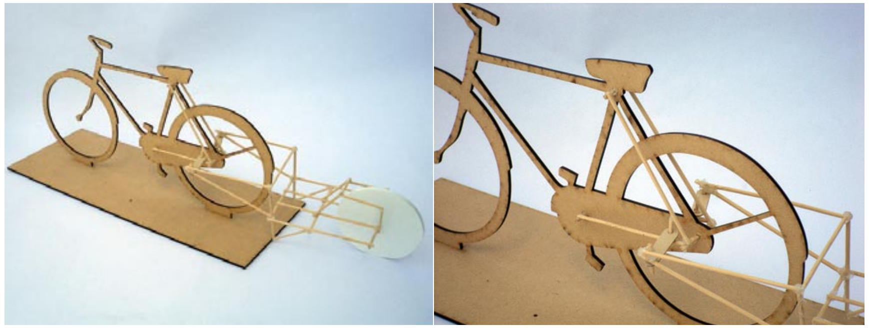


Fig 164.

Fig 165.

The same 3D software was used to produce more accurate dimensioning of each part required for these two ideas.

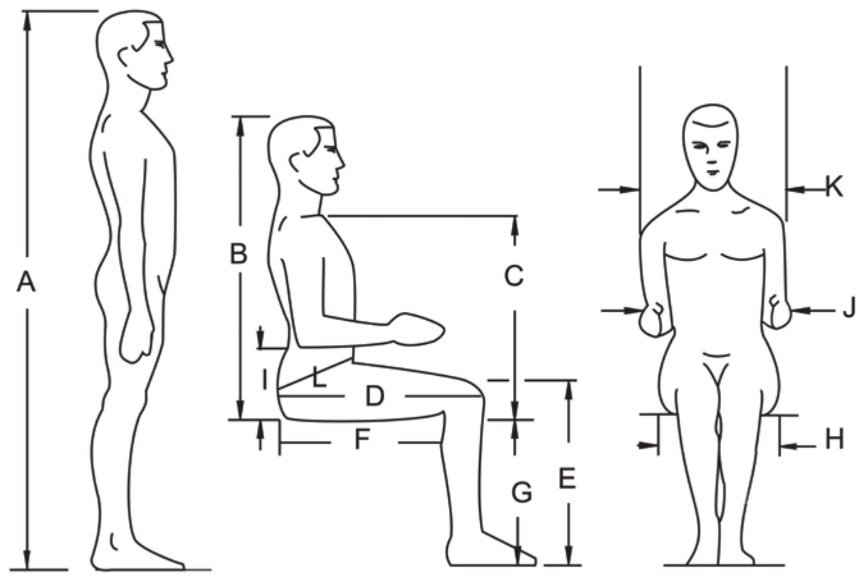
Figs 161.-165. Five mock ups of one wheel trailer and attachment concepts

5.9 Anthropometric Data

To determine the distance between the arms of the trailer to ensure the HCD was applied on the Greencycle, anthropometric data was used as a guide line. This step is necessary to maximize productivity by reducing user fatigue and discomfort when operating the wheel barrow. (The Ergonomics Society, 1996-2008).

To use the wheel barrow comfortably, the user's arms are best to be straight down and close to the body. By analyzing the highest percentile of elbow room for the highest percentile of average males, the width dimension of the trailer's arms can be calculated. Having a 500mm space between the two arms would allow for the biggest percentile of males to fit between the arms.

Anthropometric data was also used to analyze the length of the arms to the centre of the wheel. The highest percentile of Indonesian male heights was applied to find the most suitable angle, so the lower angle will always be at the opposite end to the user to ensure the load weight distribution will always be at the wheel centre. To make the wheel barrow safe to pick up when loaded, the physical action required is no different to picking up a heavy box off the floor. The user needs to stand between the arms of the wheel barrow, bend their knees and squat down while keeping their back straight. (IAPA. 2008)



	DIMENSION	5% Female	95% Male
A	Standing Height	59.0"	72.8"
B	Sitting Height	30.9"	38.0"
C	Shoulder Height	18.0"	25.0"
D	Upper Leg Length	20.4"	25.2"
E	Knee Height	17.9"	23.4"
F	Seat Length	17.0"	21.6"
G	Seat Height	14.0"	19.3"
H	Seat Width	12.3"	15.9"
I	Elbow Height	7.1"	11.6"
J	Elbow Room	12.3"	19.9"
K	Shoulder Breadth	14.4"	19.6"
L	Hip Circumference	37.0"	44.5"

	5th Female	95th Male
Weight	104 lb	241 lb

Fig 166. Source: Woodson (1981)

The higher the wheel barrow arms are from the floor the easier and safer they are for the user to reach. However, compromise is needed to make ensure it also functions well as a trailer.

The bigger the wheel diameter means the lower the arm position as a wheel barrow unless the support stand's height is increased. However, if the support stand's height is increased too much, this can cause problems when a smaller diameter wheel is used on uneven rural road surfaces. One solution is to step up the arms to increase their height instead of increasing the height of the support stands. It is important to find the right balance to ensure both functions, as a wheel barrow and as a trailer, achieve the optimum outcome.

Based on a journal written by the University of Airlangga Indonesia, the average height of a young male adult in Java, Indonesia is 1.624 millimeters (5 feet 4 inches). Based on earlier research methods, the most common bicycle wheel sizes used in Indonesia as a work horse are 20", 26" and 28" diameter wheels. Using this combined data, a scaled diagram can be created to illustrate the relationship between the user and the wheel barrow to ensure its safe operation.

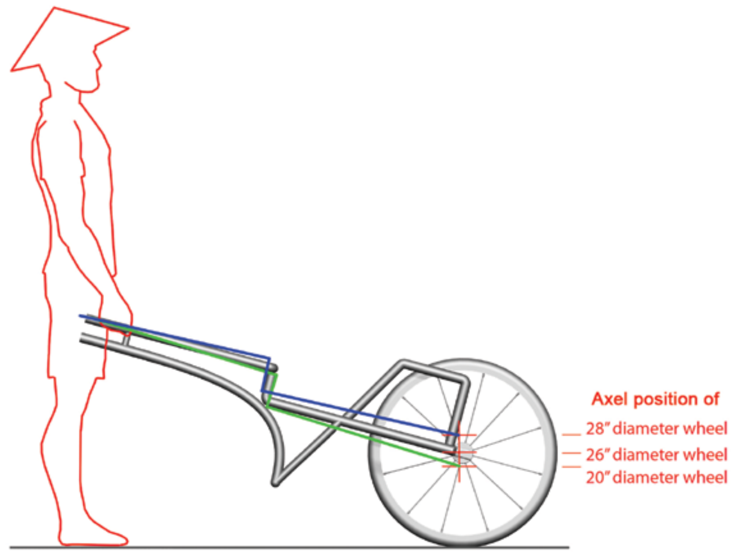


Fig 167. Diagram A (standing up)

Diagram A (Fig 167) illustrates the user in an upright position when operating the wheel barrow with a 26" diameter wheel; the blue line represents the wheel barrow angle when a 28" diameter wheel is used while the green line represents the wheel barrow when a 20" diameter wheel is used.

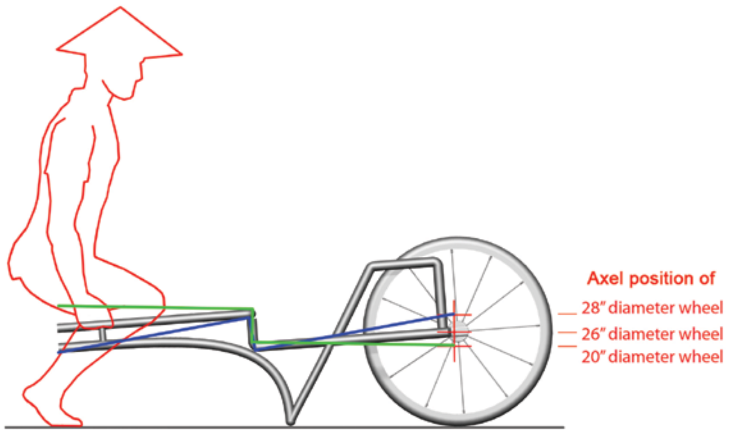


Fig 168. Diagram B (picking up)

Diagram B (Fig 168) illustrates the user in a squat position when picking up the arms of the wheel barrow with a 26" diameter wheel, the blue line represents the wheel barrow angle when a 28" diameter wheel is used while the green line represents the wheel barrow when a 20" diameter wheel is used.

Therefore informed overall dimensions of the trailer frame can be determined – Width: 500mm, Length: 1200mm with the arm tubes sitting 100mm higher than the platform and the stand supports 250mm below the platform.

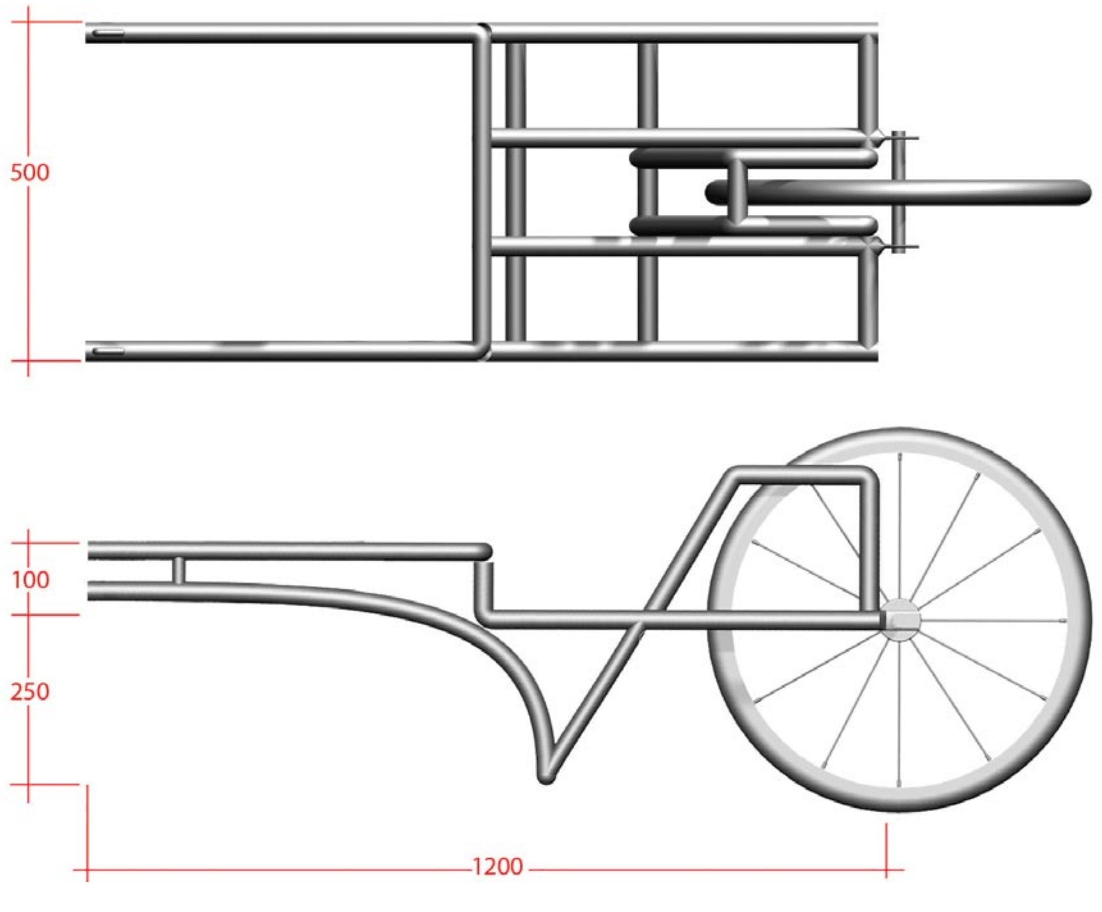


Fig 169. Diagram C (trailer dimensions)

5.10 Proposed Design Trailer Bracket A

This design focused on the use of space between the seat and chain stays on the bicycle as the main joining point. Most parts were welded together and made of existing standard steel extrusions currently available on the market to avoid any extra part costs through secondary manufacturing processes.

Two steel channels were attached to the seat and chain stays to create a bridge for the swing arm to be placed which functioned as the joining point to the trailer. The top steel channel was made so it could be pivoted to overcome problems with variant seat stay angles on different bicycles. This allowed the bracket to fit most diamond framed bicycles. The trailer could then be easily attached to the bicycle by placing the vertical steel rod attached at the end of the trailer arms, into the swing arm ring. The swing arm not only acts as a joining point but also allows the trailer to move from side to side using the same principle as a door hinge. With two swing arms on each side of the bicycle, smooth movement can be produced when cornering.

Another system needs to be added to allow the trailer to move up and down on uneven road surfaces. This can be overcome by creating another pivot point at the joining. However, by adding another moving part onto the bracket system will add to its complexity. Where there are more moving parts this potentially means more things can go wrong and will add further costs to the production process.

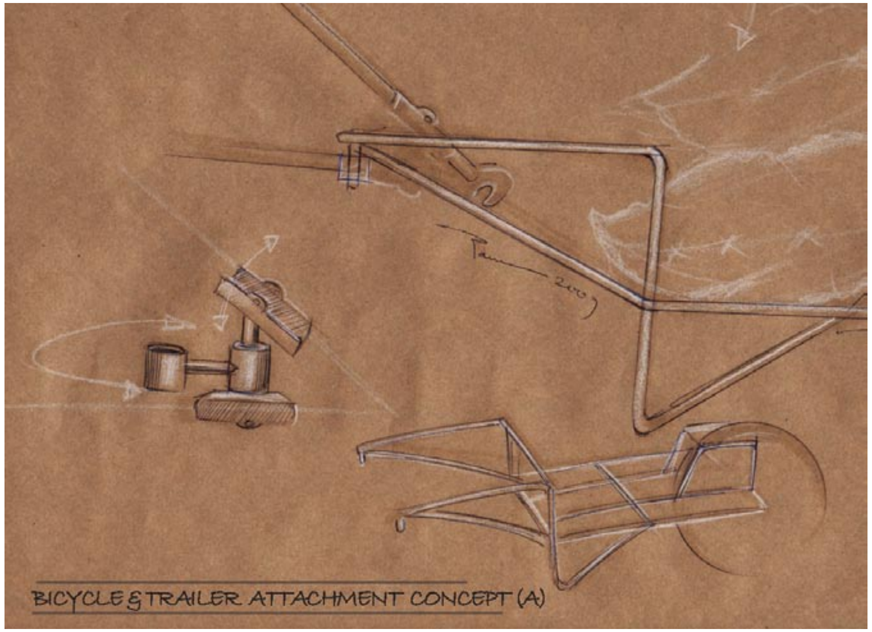


Fig170. Concept sketch of design bracket A

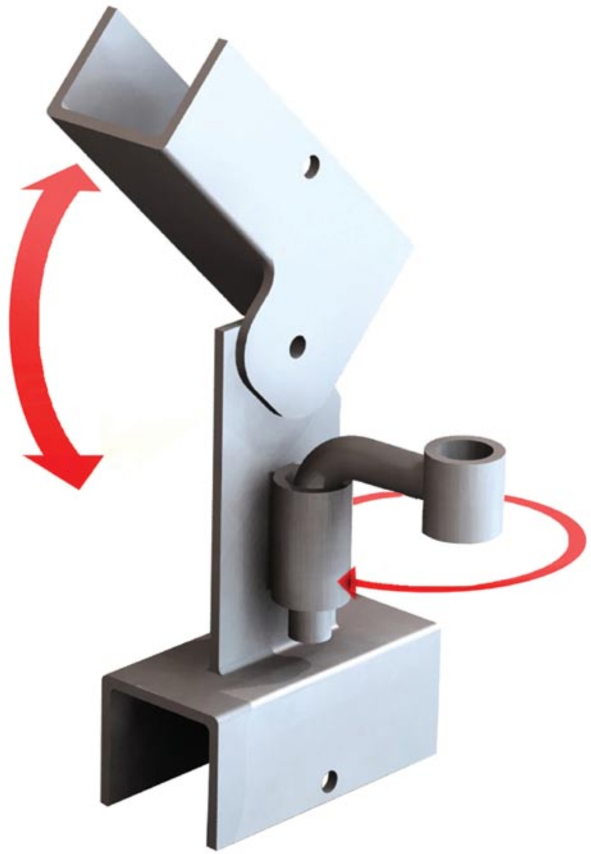


Fig 171. CAD rendition of design bracket A

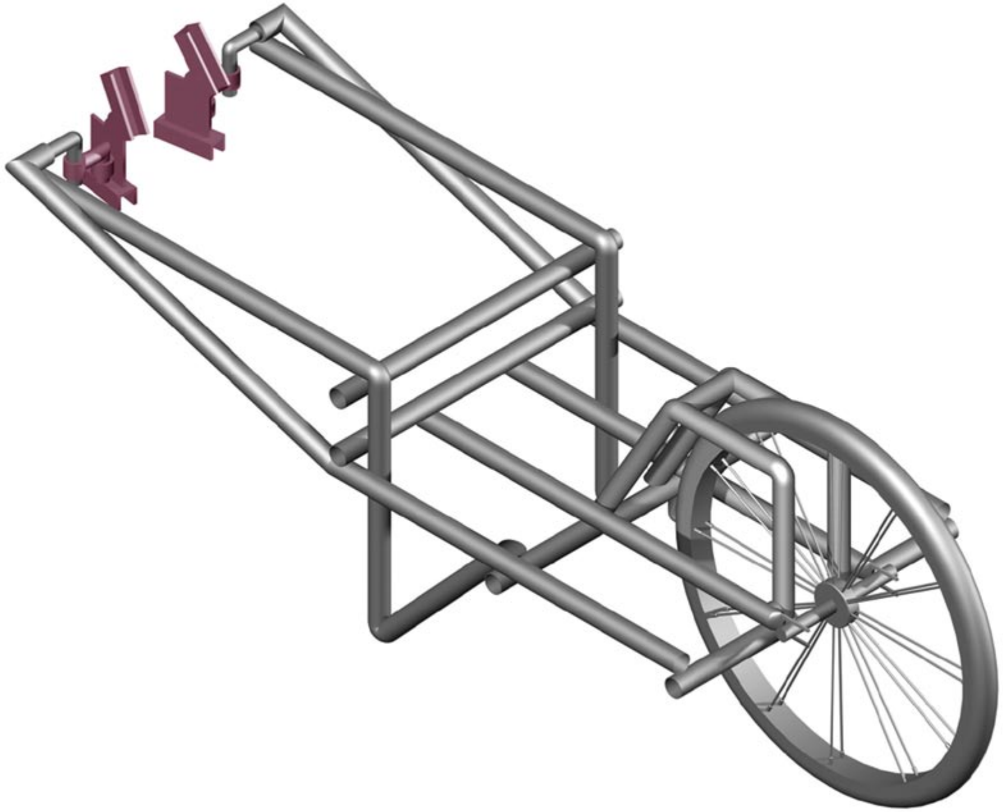


Fig 172. CAD rendition of trailer and bracket A

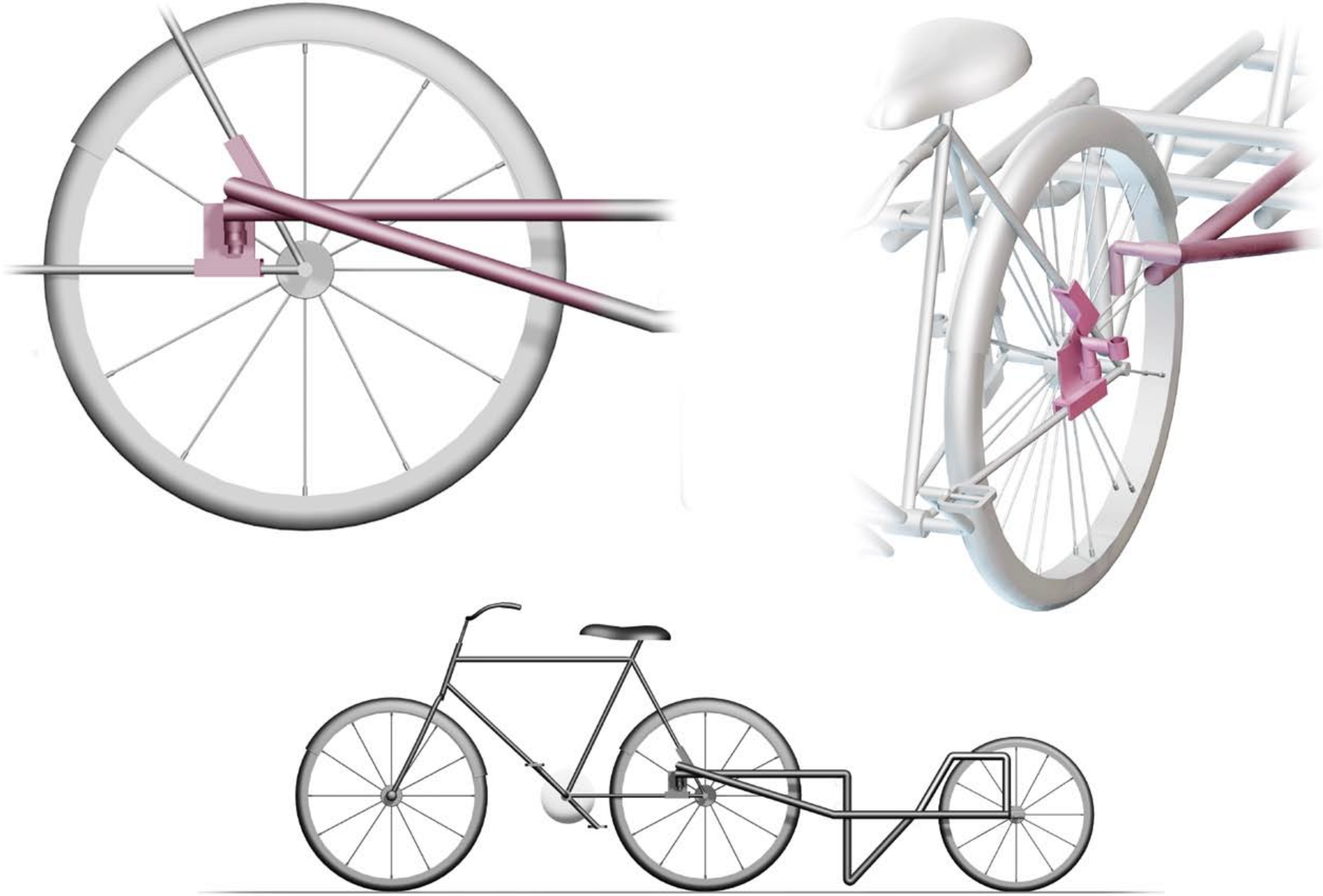


Fig 173. CAD rendition to illustrate the joining system of trailer A

5.11 Proposed Design Trailer Bracket B

This design focused on using the bicycle's rear axle as the main joining point. The axle extension works as a replacement to the main bolt that holds the rear tyre onto the bicycle frame. A vertical angled arm is attached to a sleeve tube which moves freely on the axle extension to overcome problems with seat stay variant angles on different bicycles. This allows the bracket to fit onto most diamond framed bicycles.

The trailer arms then simply slide toward the axle extension, placing the axle extension tube in the channel between the steel tube arms. An L-shaped steel pin drops vertically into holes at the end of each trailer arm tube to lock the trailer in place. This prevents the arms from sliding back out from the axle extension tube.

The channel on the trailer arms allows the axle extension tube to move back and forth which then allows the trailer to move from side to side when cornering. The extension tube will also work as a pivot point to allow the trailer to move up and down on uneven road surfaces.

All parts were welded together and made of existing standard steel extrusions currently available on the market to avoid any extra part costs through secondary manufacturing processes.

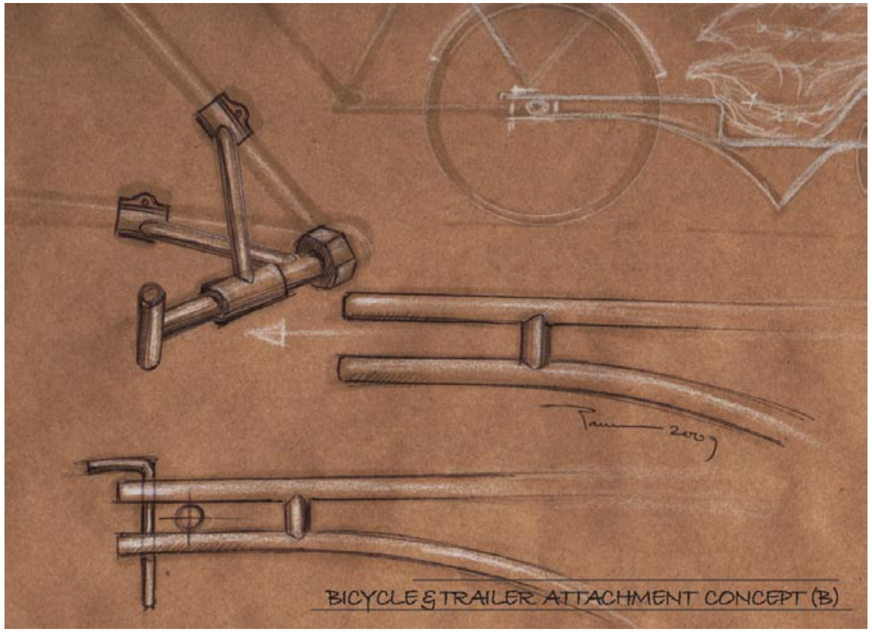


Fig 174. Concept sketch of design bracket B

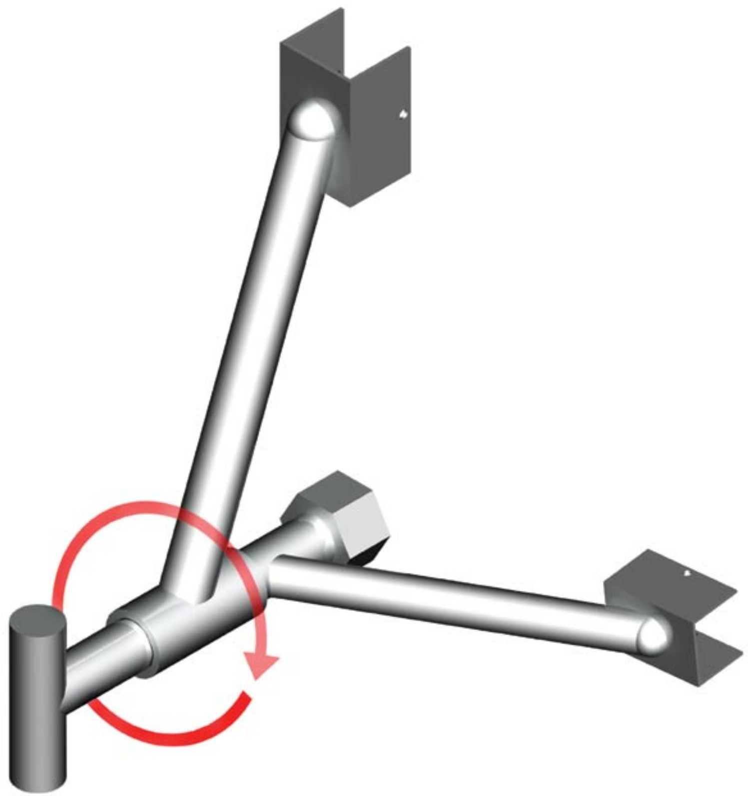


Fig 175. CAD rendition of design bracket B

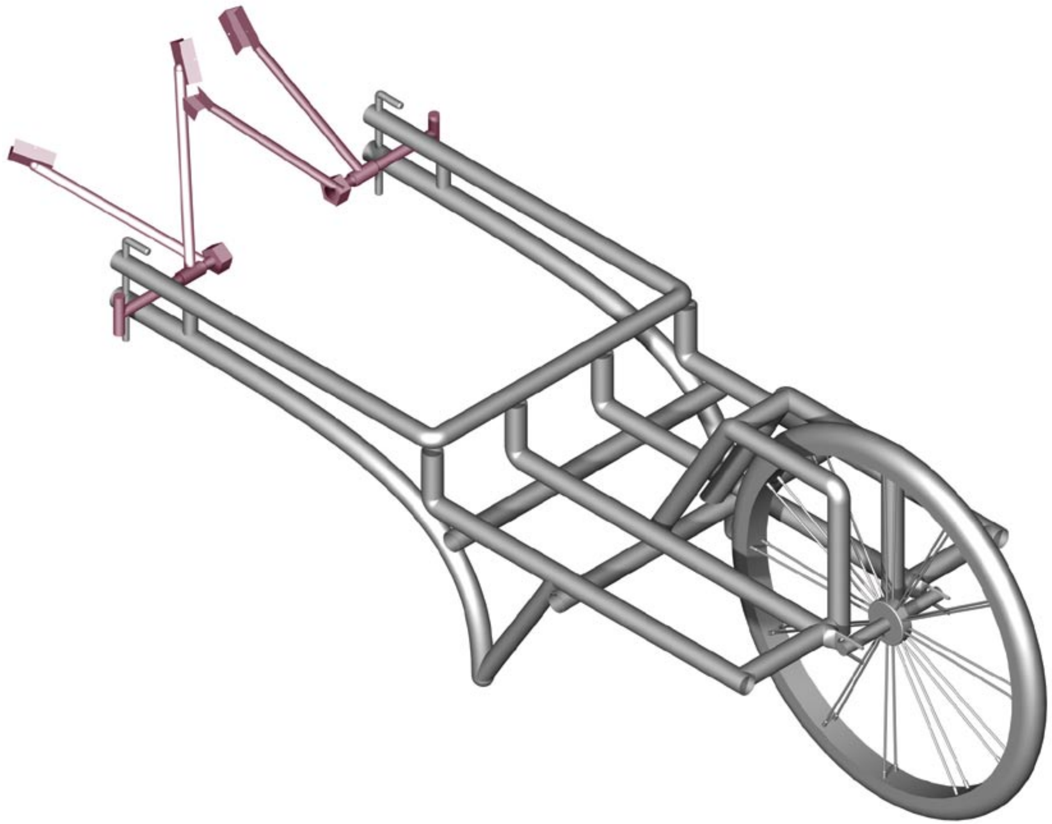


Fig 176. CAD rendition of trailer B and bracket B

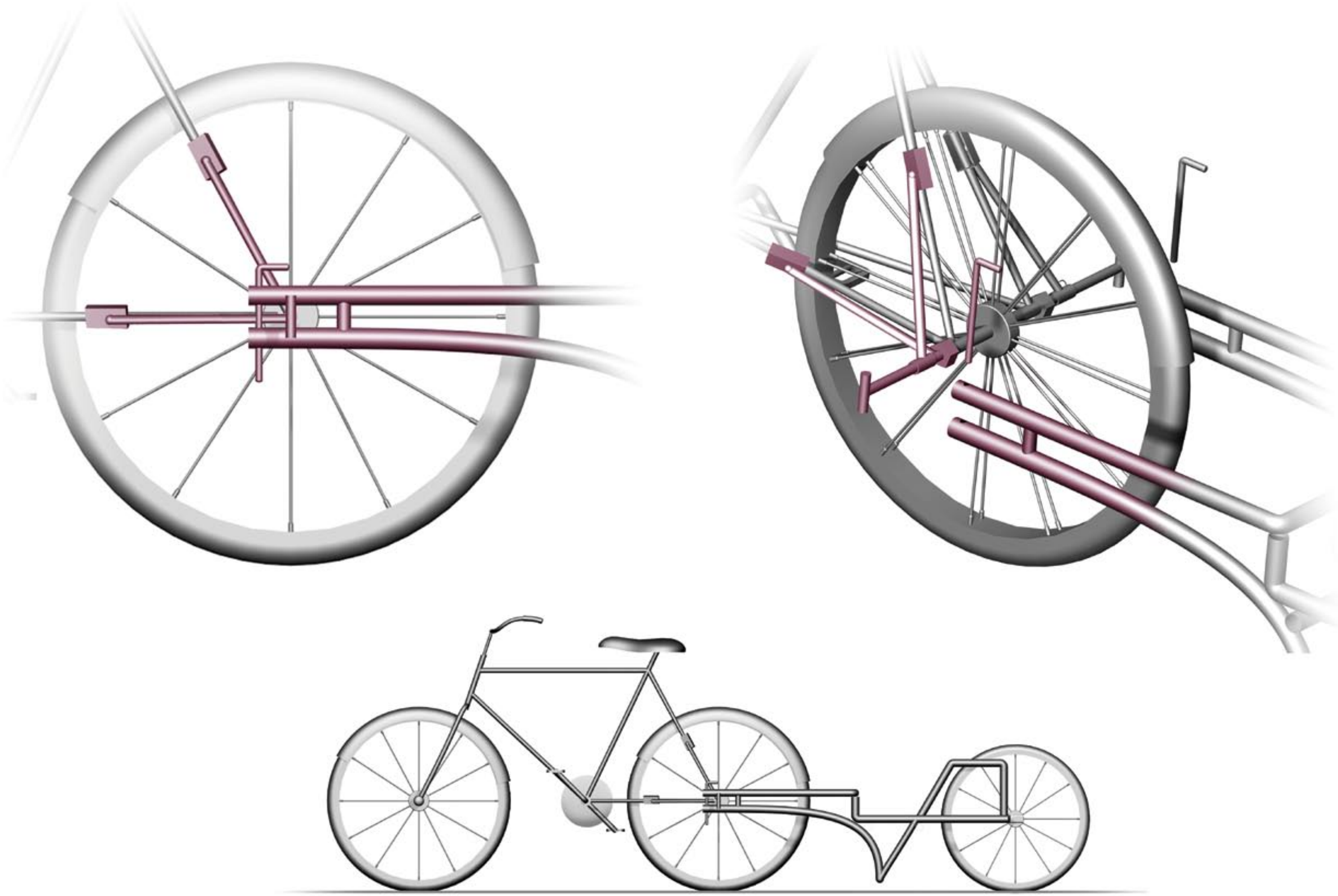


Fig 177. CAD rendition to illustrate the joining system of trailer B

5.12 Design Comparison

With both systems now built on 3D software, both systems were compared so that the most favourable system could be chosen for further development.

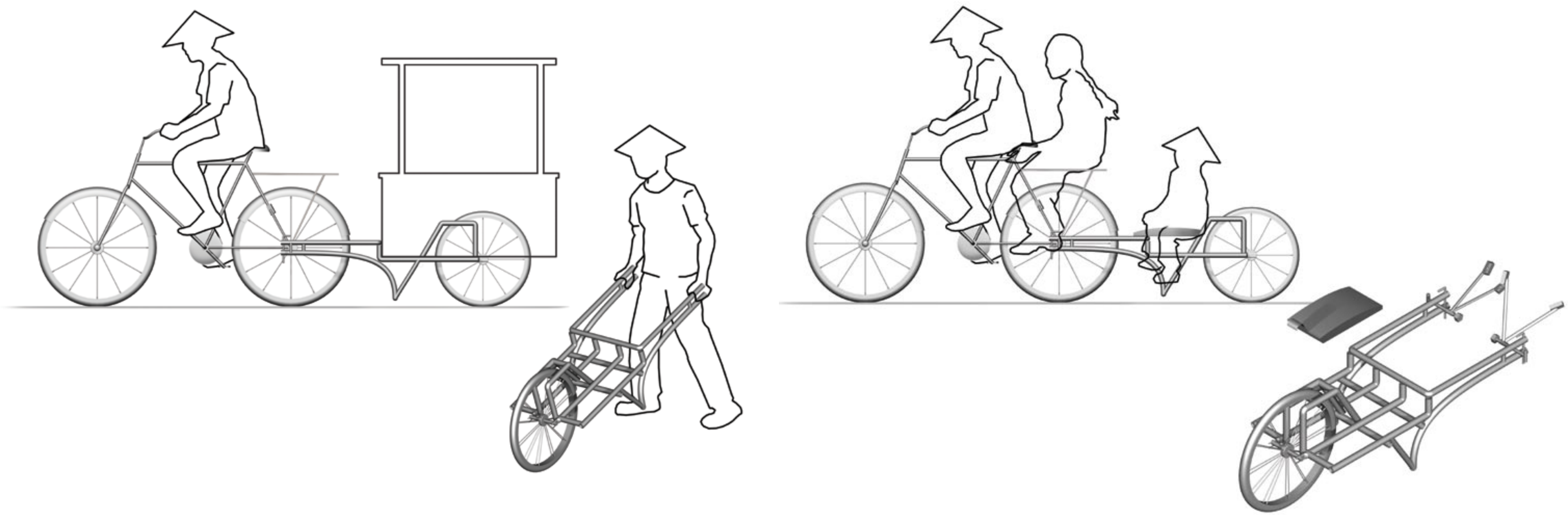


Fig 178. Proposed uses of the trailer

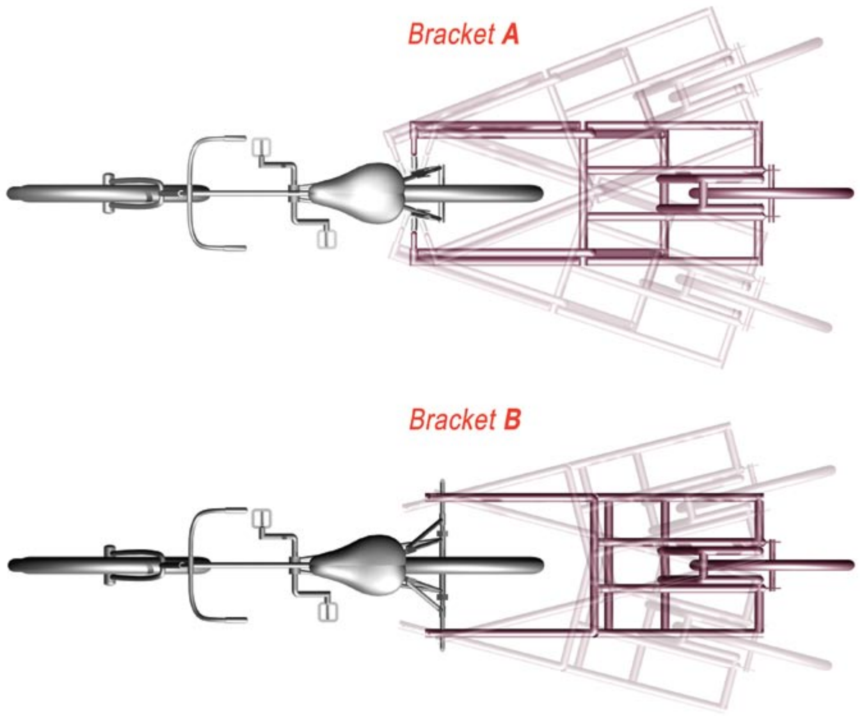


Fig 179. Diagram showing a bird's eye view of
the two trailers' movement

1. Both systems were designed giving consideration to the needs and wants of other users in similar target demographics. The trailer's construction can be potentially adapted as a platform for other user needs such as for a vegetable or fruit hawker, as a wheel barrow for movers or by attaching a simple cushion onto the trailer frame it can become a people mover system.

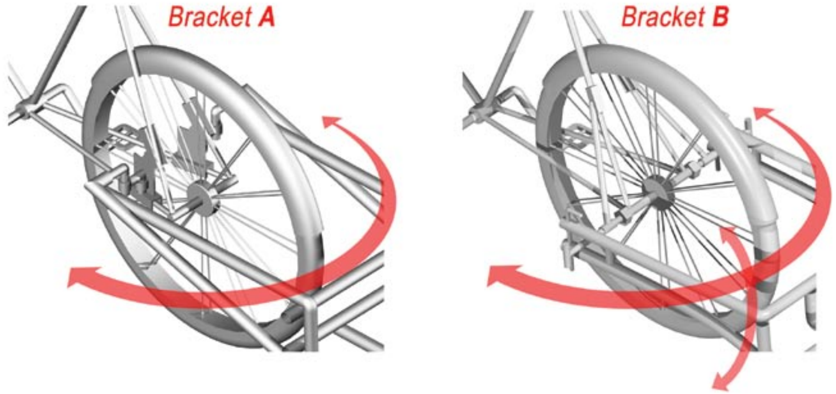


Fig 180 Diagram showing the different movement of
the two trailers

2. Both bracket systems have given the trailer better cornering ability. The turning angle for proposed design A can be adjusted by increasing/decreasing the length of the swing arm on the bracket. On proposed design B this can be done by increasing the spacing channel on the trailer arms to provide more room for the extension to slide back and forth. However, on both proposed designs, the turning radius needs to be limited to a less than 20 degree angle to prevent the trailer arms from making contact with the rear wheel. As the secondary function of the trailer is to act as a wheel barrow, by increasing the distance between the two arms to gain a greater angle is not possible. One has to remember that when cornering, one arm of the trailer will swing backwards, thus forcing the other arm to swing forward which may interfere with the bicycle pedals if the distance between the two arms increases to far.

3. Proposed design A, with bracket swing arms, will produce a smooth side to side movement compared to proposed design B which produces side to side movement by sliding the trailer arms on the axle extension tube. Design A requires more time (in labour) to produce whereas design B has fewer moving parts which means quicker production time. However, the biggest disadvantage of proposed design A is that it only allows for a side to side horizontal movement of the trailer whereas proposed design B has both horizontal and up/down vertical movement. This will make a big difference when operating the trailer system in hilly areas or over uneven road surfaces which are common in rural areas in most developing countries.

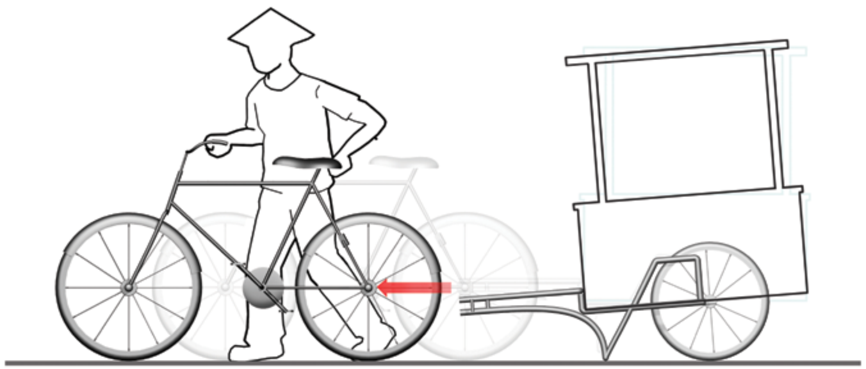


Fig 181. Diagram shows the release of the proposed trailer

4. The other advantage of proposed design B is the ease with which the trailer can be detached from the bicycle. With a loaded trailer, quick and easy detachment from the bicycle becomes critical. With proposed design A, the trailer arms need to be lifted high enough to be removed from the swing arm rings while balancing the trailer and its weight. With proposed design B, this can be done simply by pushing the bicycle forward and leaving the stationary trailer behind after removing the L-pin to unlock the trailer. This system will allow users to drop the loaded trailer without having to first unload. This enables the bicycle to be quickly ready to pick up the next trailer.

Based on this finding, the proposed design trailer B was chosen to be the trailer idea that was developed and built in Indonesia for user testing. A full-size prototype was built using facilities and technology available in Indonesia. The finished prototype(s) was distributed to target users to be tested and used. User feedback was gathered, analyzed and used to inform the final idea(s) of the Greencycle.

5.13 Field Research

Two field studies were conducted at the design phase. The first was done in early September 2009 at a local bamboo growing plantation in New Zealand to explore and conduct experiments on bamboo as a material being considered for use for the Greencycle.

The second was done in early January 2010 in a farming village at Kerawang, Indonesia, to conduct prototype testing. The aim of this field research was to collect primary information rather than relying on published material. Field research to test the prototype was used to gather information regarding the target user response. Human responses can be difficult to measure whereas field research can provide new insights on this subject thus avoiding any assumption and rationalization.

5.13.1 Bamboo Parts

Even though bamboo in general is a very strong material, for the purpose of this project it may need reinforcing with a steel bracket at the joints. This idea has been illustrated by Brano Meres in his bamboo frame bicycle which requires the use of non-recyclable materials such as polyurethane foam, carbon fibre cloth and epoxy resin to increase the rigidity of the bamboo rod at the joining points. All these added materials not only made the bicycle non-recyclable but also increased its production cost. (Meres, 2004)

Fig 182. BMC bamboo joints

Fig 183. Calfee bamboo joint

This point has also been reinforced by Craig Calfee and his "Bamboo Bike in Ghana". He stated that his bike was hard to build and required a significant amount of labour to produce. He used fibre from a local forest vine to wrap the joint at the intersecting points. To process it into fibre, it required heating over charcoal, being beaten with a stone and pulled apart by hand which was very labour intensive. His commercial bike uses natural hemp for joining which also requires a few processes from its raw material state before it can be applied. (Calfee, 2009)

These two case studies have highlighted the importance of the joining points on a bicycle. It is the intention of this research project to explore other ways that have not yet been looked at by other projects with similar interests on the subject. This begs the question: How can this joint bracket be designed to accommodate all bamboo diameters?

It is always an option to design several different sized brackets to choose from, like gloves which come in large, medium and small sizes. However, it will be uneconomical to produce different sized brackets, even though they can be designed identically in form. Moreover, there will be a different bracket design for different tasks so the cost can easily escalate higher. This also involves labour intensive processes even before considering that the two ends of bamboo won't be identical in diameter size.

The second option is to design an adjustable bracket which can be adjusted to fit various sizes of bamboo. Thus the bracket needs to be made up of two or more moving parts. Moving parts in general need more attention and care for them to perform flawlessly. To have more parts also creates more tasks and there is always the chance of parts going missing. Without complete parts the design will not work in the way it's intended, especially in the environment in which the Greencycle will be operating. This could create frustration due to not being able to get replacement parts.

The third option is to design and produce a single sized bracket and try to regulate the diameter size of the bamboo. Using the knowledge gained from the case study of square bamboo, it may be possible to manipulate only certain parts of the bamboo stem without treating the whole. To verify the possibility of this option, field research and experiments need to take place.

"We have to learn again that science without contact with experiments is an enterprise which is likely to go completely astray into imaginary conjecture."
(Alfven, 1908-1995)

The idea for this field experiment was to see if certain parts of bamboo growth can be contained in form and size to create greater consistency in parts for better and easier construction of the Greencycle. This experiment had the advantage that outcomes were observed in the natural setting instead of in a controlled laboratory environment.

Field experiments contrast with laboratory experiments which are done in a controlled fashion and with more precision. The certain environment of the laboratory is often used in the social sciences, especially with health intervention. (Harrison & List, 2004)

However, a field experiment risks contamination and the outcome could vary because of the effects of natural elements such as weather, strong wind and insects or even human error. Nevertheless, it was imperative that this experiment was conducted in the natural environment to produce a true result.

For the purpose of this research project and its time constraints, a smaller bamboo species known as Bambusa Alphonse Karr was chosen for the field experiment simply because it was easier to deal with and matures faster than bigger species. At first, a series of steel caps were made and put on a fresh bamboo shoot. The idea was to have a reusable cap or bracket that could be easily put together by a screw or bolt. However, this could slow down the complicated process and costs may accrue in the making of these caps. What seems to be a simple process may not be for people in Third World countries. It is not only the cost and availability of the chosen materials but also the lack of infrastructure and facilities which may not exist to support the manufacturing process.

After considering the standard of living and environmental conditions of the target demographic in Third World countries, a decision was made to explore a simpler, more basic method that used commonly found objects which could be easily obtained locally from a scrap yard or landfill. Recycled products such as metal or plastic pipes, or simply using a block of wood that has been drilled or had a hole cut out and split into two would perform a similar task to the cap

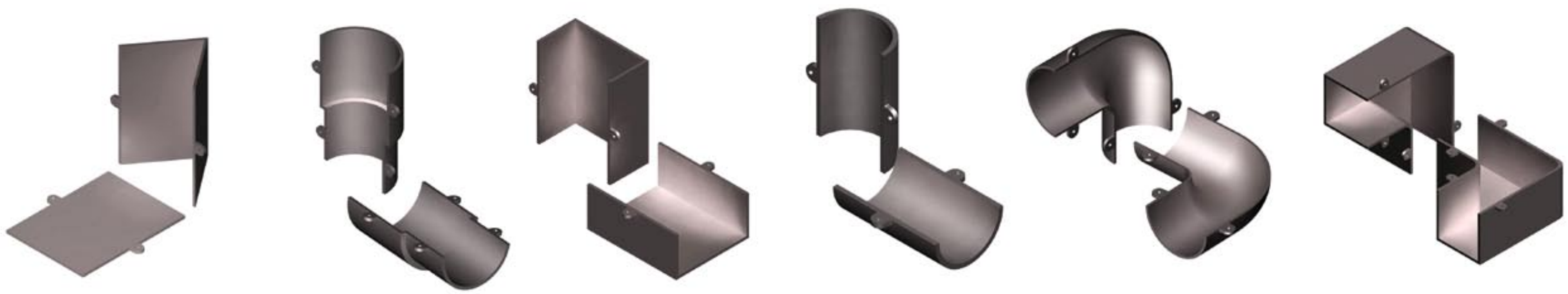


Fig 184. CAD rendition of proposed steel caps

or bracket as earlier thought.

Before the field experiment was conducted it was necessary to have a basic knowledge of bamboo and its environment. Preliminary research was conducted by visiting a local New Zealand bamboo grower who runs one of only two bamboo farms in the North Island of New Zealand. This part of the research was simply to gain basic information and insights into bamboo properties which then can be used to formulate an ideation process and the field experiment.

A set of questions was formulated and sent via email prior to the visit, focusing on bamboo properties such as strength, size and looking at the existing process of preserving bamboo in the most natural way without using chemicals. All this information was important for verifying the idea of bamboo manipulation. Answers gathered from these questions helped to inform and prepare for the one-on-one interview on the site visit day. This helps in keeping an open mind and prevent a predetermined mind set or assumptions which often lie below the surface unconsciously.

An open mind looks at the significance of its evidence with the same dispassionate attitude it applies to its premises and assumption. The open mind asks, "What verification do I need to gather? Do I know enough? Has anything changed since I last collected evidence? Is there new information? Are my facts complete? (McKenzie, 2004)

However, an open mind without a clear goal in sight could mean a journey in total darkness. A set of goals needs to be formulated to help synthesize new information or data to give direction closer to the desired outcome.

From the information that was gathered from the questionnaire (Index F), it was established that bamboo is a very resilient and fast growing type of grass which pretty much can survive in any climate. Even in a poor environment it can still produce good results but bamboo is best suited to tropical countries. Also, it's easy to reproduce and needs relatively low maintenance. Simple methods such as fertigation or spray manuring can optimize the growing process. Bamboo varies in size and strength. Soil quality and the ideal length of growing time are required to reach its optimum desirable timber strength. It needs 1-3 months to dry naturally, this process can be speeded up with kiln drying to remove moisture and sap. A high temperature oil treatment is the most natural way to preserve bamboo from degradation; hence some work involving additives has been undertaken.

5.13.2 Visit to a Bamboo Plantation

A bamboo plantation at Oratia in Auckland was visited in early September 2009. The nature of the visit was to get a better understanding of bamboo in its natural habitat and undertake the expert interview. This bamboo plantation was established in 1943 and has been the biggest bamboo product supplier in New Zealand ever since. There are over 100 species in their collection which were mostly imported from different parts of the world in the 1950s before import regulations became more stringent (see Biosecurity New Zealand, http://www.biosecurity.govt.nz/enter/plants).

The expert explained that every plant they grow is checked for consistent viability so that every item they hand produce has its optimum intrinsic quality and every design has sufficient endurance. They are well acquainted with bamboo and were able to provide advice on all aspects of its use and application. This expert has an extensive knowledge of bamboo products and processes and believes that bamboo will be a perfect substitute to wood when the potential of bamboo is fully understood.

Fig 185. Interviewing bamboo grower

The nature of the Greencycle project and its intention for target users in Third World countries was explained to the expert. The intention of the field experiment was also discussed. The expert pointed out that the best time to do the field experiment was at the beginning of November when the bamboo starts producing shoots.

When asked if bamboo will be a suitable source of material to use in Third World countries, the reply was; “bamboo is a strong and very economical material which is abandoned in most parts of Third World countries”. In India, bamboo is known as the ‘poor man’s timber’ while in China it is considered a valuable raw material for their booming industry.

When asked if bamboo was safe and strong enough to be used as a material for human powered transportation, the reply was; “bamboo has been widely used as an architectural material and has been proven stronger than concrete in compression tests”. Therefore bamboo is more than adequate to be used as the main material for human powered transportation

When opinion was sought regarding methods/ processes to improve bamboo conditions with a focus on sustainability and natural materials, the expert was happy to demonstrate a way of sealing the bamboo by rubbing it with a product made of lanolin. Another natural preservative like beeswax balsam is also a good product to protect and renew the life of bamboo.

The word “lanolin” is derived from the Latin “lana”, meaning ”wool”, and oleum, meaning “oil” – a greasy yellow and soft waxy material from the oily coating on raw wool. Most lanolin is extracted from wool when it is processed into textiles such as yarn or felt. Lanolin has a water proofing property which helps sheep to shed water from their coats. This water repelling property makes it perfect as lubricant grease. (Answer Corp, 2009)

The expert emphasized that the inner tube of bamboo is more susceptible to moulds and insect and beetle attack as they love the starchy liquid of fresh cut bamboo as a meal. It is very important to treat the inner tube surfaces and seal the ends to prolong its usefulness. One of the more common sealing processes is to heat fresh bamboo over a fire or flame until wax beads build up on the surface which can then be rubbed to buff the bamboo surface to a lovely sheen. This will give the bamboo a natural protective shield. However this natural protection can breakdown over time when exposed to weather and sunlight.

5.13.3 Bamboo Experiment

A bamboo experiment was conducted during the last week of October 2009. The bamboo had just started to shoot. The experiment started with a trip to the scrap yard of a local engineering manufacturer to look for used tube pipes in various sizes and shapes. The reason for this was to see if the experiment could be done by utilizing recycled materials or other common extrusion products instead of specially made brackets. This would help mimic the likely scenario in a Third World country and would give a greater understanding of the problems that may be incurred through this process.

Papanek (1984) said there is much we can learn from developing countries about living patterns, small scale technology, reuse and recycling materials and having a closer fit between man and nature. It turns out cylindrical tubes were easier to find compared with triangular or square tubes however, square and triangle shapes can be formed by using two 90 degree angle extrusions opposing one another. Furthermore,

Fig 186. Found objects

relying on recycled product may cause some problems with consistency of material dimension so a secondary process may still be needed to make use of these found materials. Also considering conditions in Third World countries, a block of timber was also used in the experiment as this material is easier to obtain and definitely cheaper compared to steel, aluminum or plastic piping. Steel products are worth money so it is more likely to be sold to a scrap yard for a small price rather than be re-processed as a raw material.

Fig 187. Recycled timber is commonly used as a main construction material in Indonesia

This view is also reinforced by information gathered from earlier research methods. Most people in Third World countries have been modifying their human transportation to suit their needs using off-cuts, found timber or ply wood. Another advantage of wood and timber is it can be easily shaped to a desired form using relatively low technology unlike steel which requires more energy to process.

Fig 188. Creating a simple bracket using found objects and recycled materials

To start this experiment, all found tubes needed to be cut and split into two pieces so that they could be wrapped around fresh bamboo shoots or fresh stems and tied with wire. Some of these found tubes turned out to be too big in their size diameters for this bamboo species and so were eliminated.

The list of brackets made from found objects were as follows:

1. Timber blocks were drilled and sawed into parts and screws were used on one of 1. them just to make sure it was secure.
2. One found plastic elbow joint hose connector was put on a fine fresh flexible stem, 2. hoping to create an indentation as well as a corner or bend in the bamboo.
3. One found nylon tube was used whole and intact due to realizing the difficulty in 3. securing the pieces together because of its inherent slippery surface. However this material characteristic allowed the tube to be fitted onto the shoot by sliding it downward from the top end hoping this would also allow the tube to be released more easily when the bamboo was cut.
4. An angled aluminum strip was used to create a triangular bracket by putting 4. together two parts opposing each other.
5. A U-channel aluminum strip and an angle strip were used to create a square 5. bracket.
6. Also a found stainless steel hose clamp was used as a clamp which could be 6. adjusted using a simple screw driver which was ideal for this experiment.
7. One aluminum cylindrical tube and one plastic hose connector was used to 7. complete this list.

Each bracket was placed on a single young fresh

Fig 189. Bamboo experiment

stem which started coming up from the culm. Due to the nature of this bamboo species, being a dense tight cluster, some spot marking was needed. Other branches around it were cut to give clearance and better exposure to sunlight with each stem being marked using a white recyclable ribbon made of a material called Tyvek.

The Bambusa multiplex Alphonse Karr species of bamboo was chosen for this experiment. Commonly known as Alphonse Karr, it is named after Alphonse Karr Young, honouring a 19th century French botanist and novelist. This species is one of the best bamboos to use for when it is grown in well-lit conditions and outdoors it can grow up to 12 meters high. It grows in a very tight cluster of canes and is commonly used as an excellent screen to give privacy. (Farrelly, 1984)

"The history of progress is littered with experimental failures. This 'right to fail' how ever does not absolve the designer from responsibility." (Papanek, 1984)

The site was revisited five weeks after the experiment started to view progress. The results were not as good as expected. However, looking back at the case studies, they showed that the best results were only achieved after a number of experiments over a long period of time. The technique for square bamboo took years to perfect with many trials before it became available to the public. Perhaps five weeks is a little premature to see the full results of this experiment. The bamboo growth was not as fast as predicted. The square, triangle and three cylinder brackets were still unmoved or tightened by the shoot growth however the two wooden block brackets showed signs of force from the outward growth of the bamboo. A gap had formed in between the join, so extra wires have been added to hold the two pieces together. The elbow joint was also showing positive signs as the stem has grown longer and was looking healthy where it was predicted the stem would die from the bend when fitted into this bracket.

The results of this bamboo experiment may only contribute in a small way to this research project as issues arising at this time may not be able to be rectified due to time constraints and the seasonal nature of the experiment. However, there is enough literature regarding plant manipulation such as “Square Bamboo” (Bess & Wein, 2001) to suggest that it is possible to control and regulate the growth of the plant to increase the value commercially and in practical terms.

Fig 190. Envisaged bamboo parts

To support and illustrate the outcome required for this research project more experiments will be conducted in the future to achieve the desired result as illustrated in the next image.

5.13.4 Bamboo components

The aim of the bamboo experiment was to create simple components that are made from a renewable and recyclable material without using complicated recycling or disposal processes. The idea of being able to produce simple bamboo folds in various forms, such as a 90 degree angle, makes the bamboo more versatile in its application for the Greencycle research project.

Fig 191. Formed bamboo pole

Being formable will not only improve the bamboo product structurally but also reduce the number of joints required. Using the proposed trailer design B as an example, replacing the steel tubing with bamboo tubing in the frame construction would need twenty-eight pieces of bamboo. By using a bamboo tube formed at a 90 degree angle, the parts required reduce by 25% to twenty-one pieces and eight joint points are elimanated.

Regulating the bamboo (envisaged bamboo parts) growth by capping it will provide a consistent size and dimension for the attachment of the necessary steel fittings, such as a wheel bracket to hold the wheel axel in place. This would enable the steel brackets to be manufactured in one size making it more economical while avoiding issues regarding bamboo diameter irregularities.

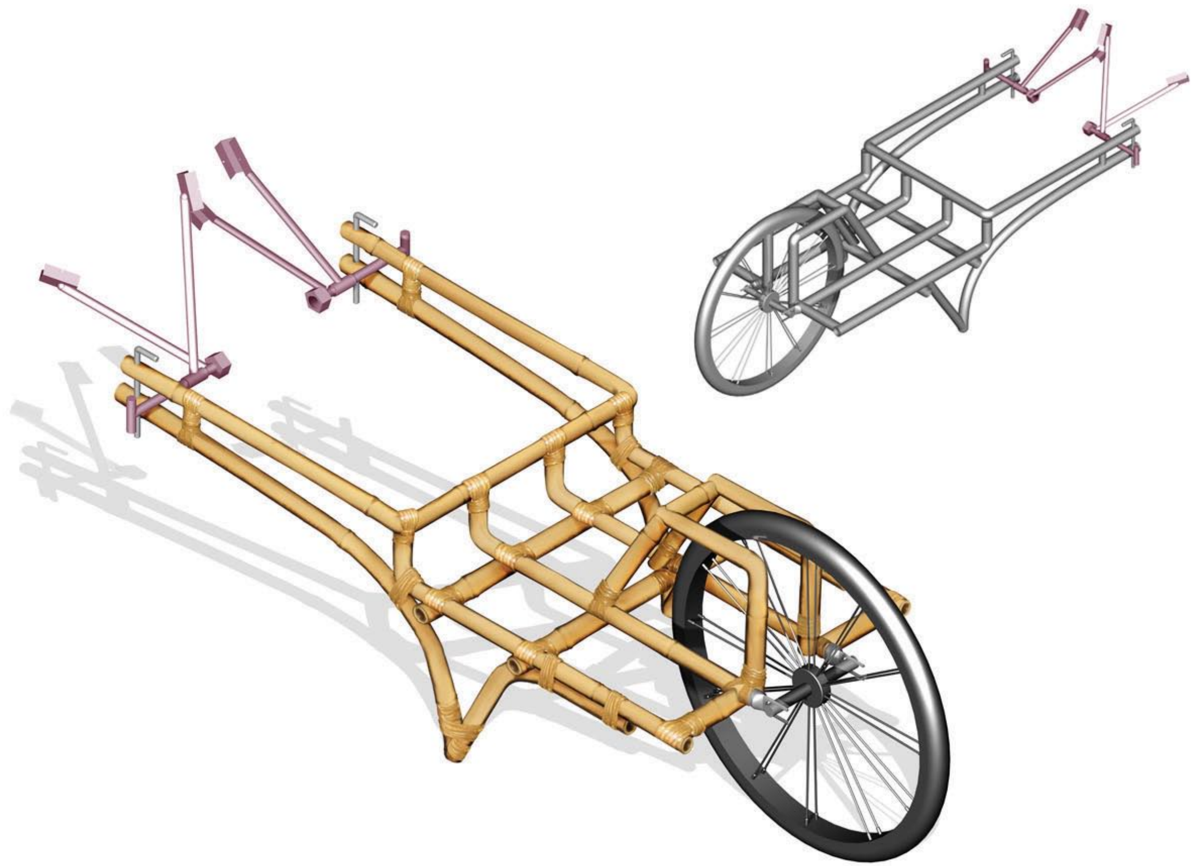


Fig 192. Concept bamboo trailer

5.13.5 Local Expertise

It is a well known that bamboo is commonly used as a building material in rural areas. Since there is no shortage in the supply of bamboo or skilled bamboo craftsmen, producing bamboo parts to be used as a form of transportation would be ideal. Besides being very economical, they could also be manufactured by local craftsmen using relatively low technology. Growing bamboo and producing bamboo parts in itself could become an income source for local entrepreneurs. Bamboo may not last as long as steel, however the cost of producing this bamboo trailer may justify its shorter life span.

On a visit to a village at Sukabumi in East Java, Indonesia, a local Indonesian bamboo workshop producing hand made bamboo furniture and baskets was selling a piece of dried bamboo, 4m in length for 7000 rupiah (about NZ$1.15). In comparison, the cost of a standard 1.5” steel tube 4m long costs 200.000 rupiah (about NZ$34). At these prices, this makes the cost of steel tube 29 times greater than bamboo, so using bamboo parts could be very favourable to the target user.

The owner of the bamboo workshop explained that the bamboo was supplied by the local villages.

Fig 193. Local craftsmen working on bamboo furniture in Indonesia

This means their buying price will be even cheaper enabling a reasonable profit on resale. This workshop employed five craftsmen from neighboring villages to hand produce a wide variety of bamboo products from chairs, tables, lampshades and “bilik”, a woven bamboo sheet made of thin bamboo strips commonly used as wall paneling in rural housing. When producing bamboo furniture, each craftsman has an individual task to do, much like working on an assembly line. The first craftsman starts by processing the raw material, cutting the bamboo to size. The next in line works on the joinery, putting all the pieces together using glue, nails and lashing it with rattan, while the last craftsman does a final quality check and gives the assembled chair a final polish. The craftsmen said they can build one complete chair in two days.

This shows that the target demography already employs "appropriate technology" that matches the tools and methods employed in transforming bamboo products from a full range of available resources in a host community – natural, material and human. These natural resources include bamboo, plants and

Fig 194. Bamboo furniture

related forest resources. Material resources include access to tools and machinery, hardware and glues, electricity, investment capital and markets while human resources include training, experience and craft heritage to be found among local craftsmen.

This working model can therefore be easily applied to the Greencycle project while promoting this type of micro industry in Third World countries. It will also help to support grass-roots communities through development and entrepreneurship. With a very small amount of training to ensure the consistent quality of the Greencycle project, the desired outcome could be achievable. However an iterative design approach is essential between the designer who supplied the design idea and local craftsman who apply the local technology to develop the proposed idea. This measured approach also encourages local craftsmen to participate in the design process and take ownership of the project.

Fig 195. Envisaged bamboo trailer with woven bamboo baskets

5.14 The Ideal Bicycle

Based on earlier design development concepts, prototypes and research findings, the ideal bicycle was created without any preconceived boundaries or limitations. This helped the researcher to explore new ideas with a focus on the target users needs and wants while taking into account environmental considerations. This was done with the full realization that not all the proposed design ideas could be implemented. However, the main intention of this "dream bicycle" creation was to simply open up the possibility for a newly invented work-horse bicycle incorporating many of these ideas.

Fig 196. Literature materials

The ideal human powered transportation has features which include:

- An extra wheel for stability – going from a two wheel to a three wheel design to create a triangular base that is stable and strong for heavy loads.
- The ability to convert back to a two wheel configuration style when the terrain requires tight negotiation – like a narrow pathway through a padi field or poor road conditions as commonly found in Third World countries.
- A splayed rear wheel base to provide a stable surface for load storage/ carrying which conventional bicycles don't have.
- Provision for a basic frame for further customization depending on the user's needs and wants, such as a hawker's stand.
- A splayed rear design has given an opportunity for a further fixing point for additional attachments.
- An attachment that has a dual purpose as a wheel barrow for loading goods and as a trailer for carrying goods.
- An S-frame shape instead of a diamond frame shape to free up and create as much space for loading.
- A strong central core acting as an anchor for other attachments, such as a people carrier.
- A stronger wheel design.
- Double front spokes to mimic the old style bicycle frame which has reinforced steel front forks.
- Some components made from environmentally friendly composite bamboo based materials which can be moulded to produce the desired form.

5.14.1 The Ideal Bicycle Ideation

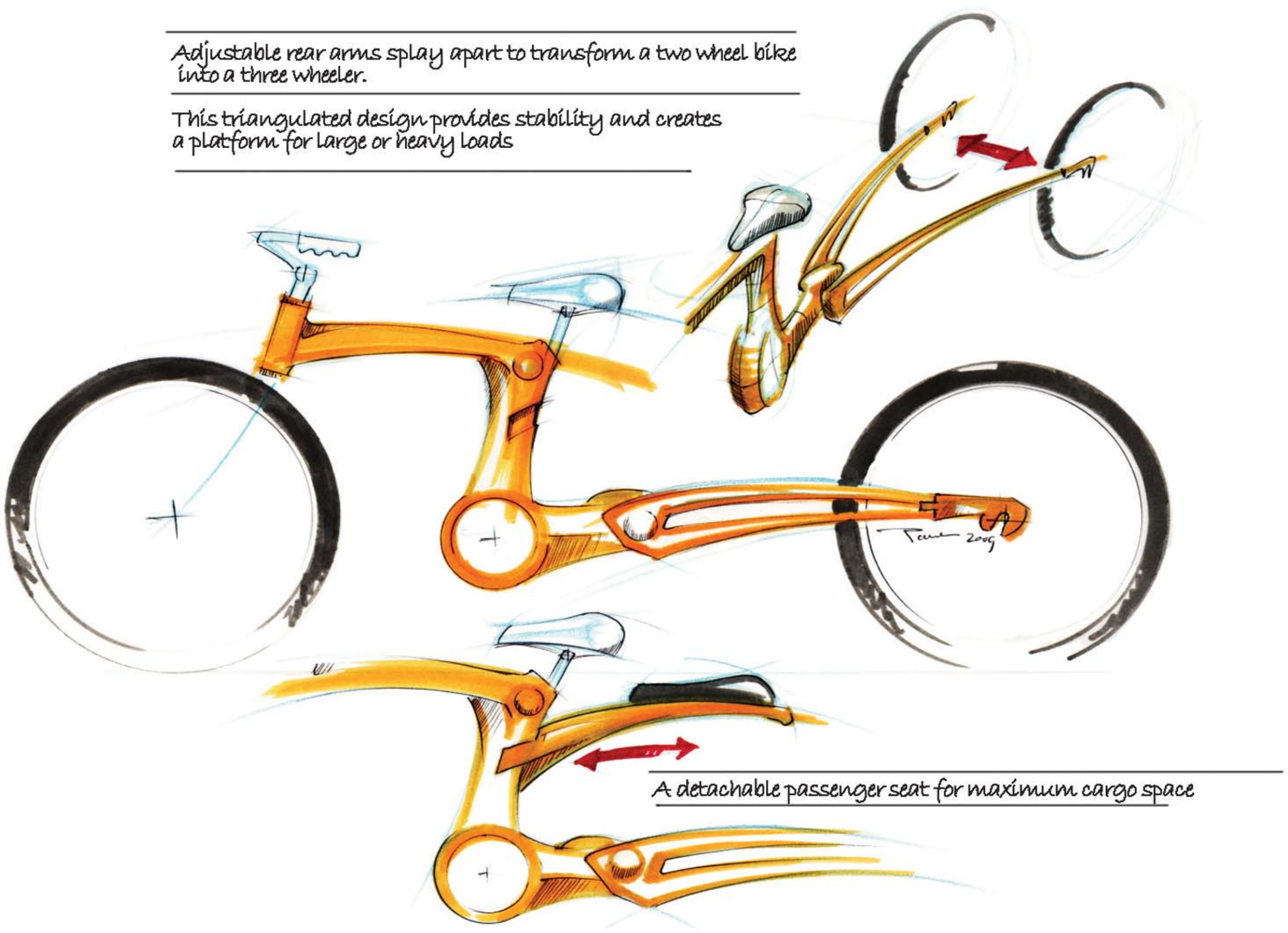


Fig 197. Concept sketch of the splayed rear wheels

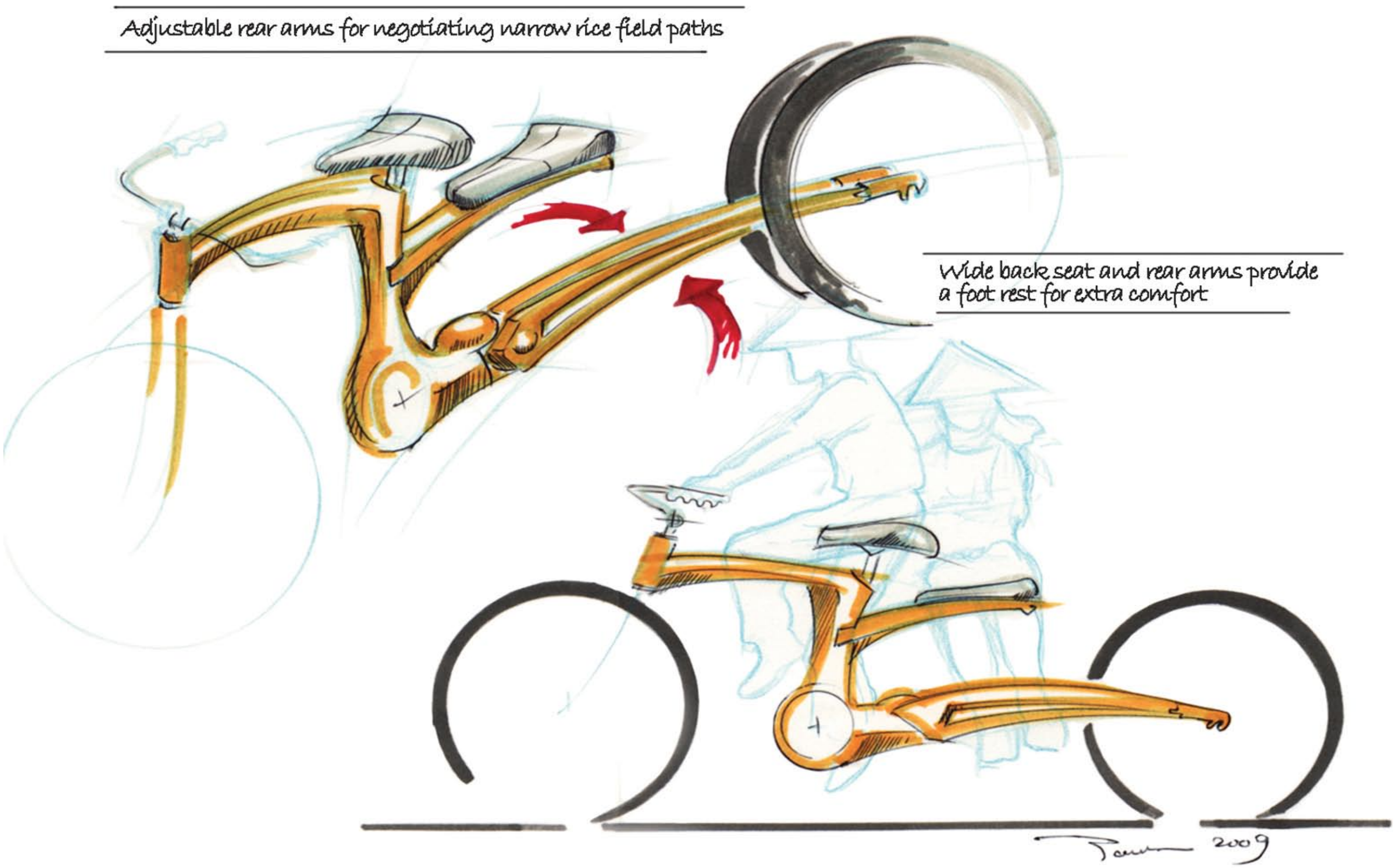


Fig 198. Concept sketch of the rear seat

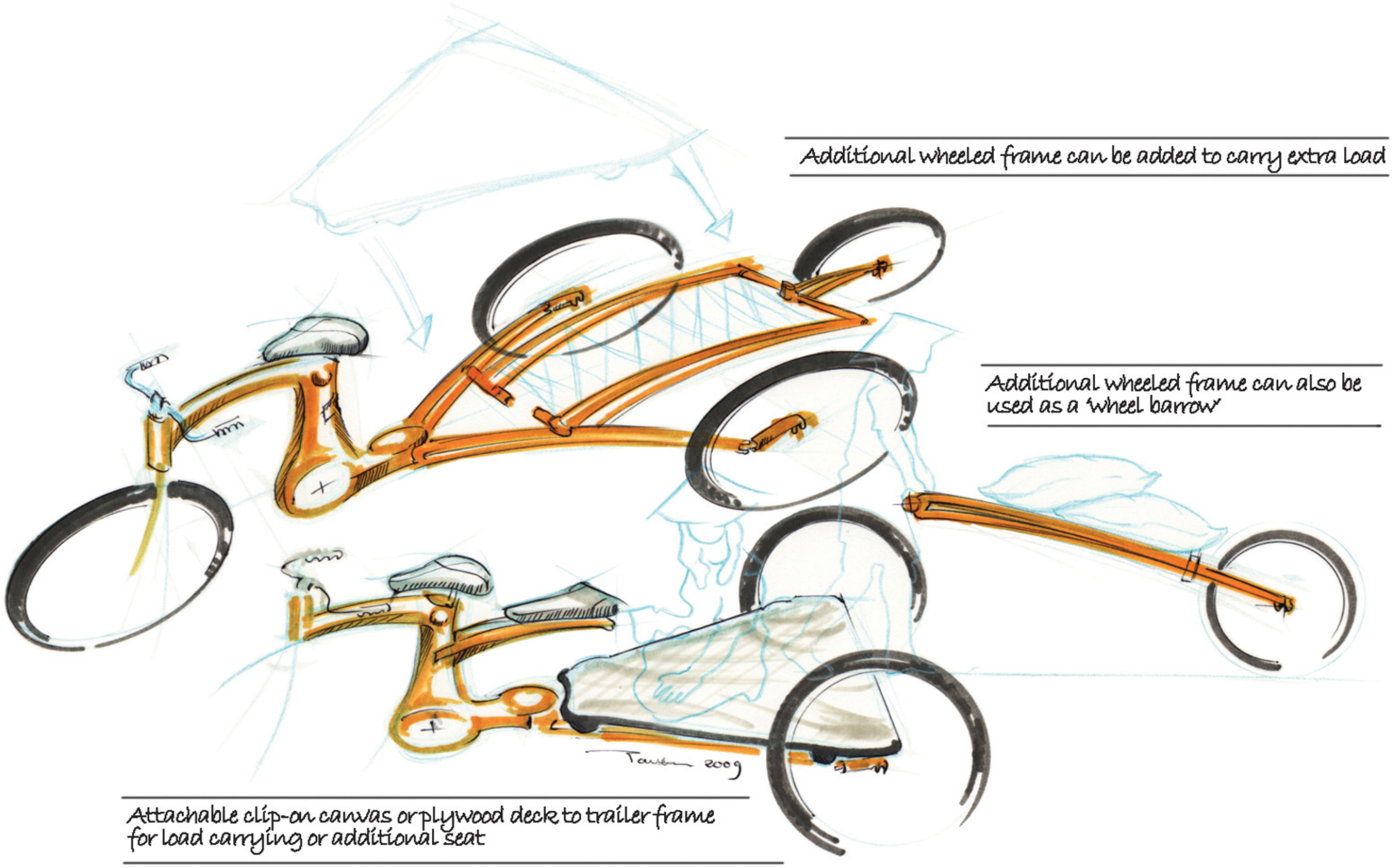


Fig 199. Concept sketch of trailer attachment

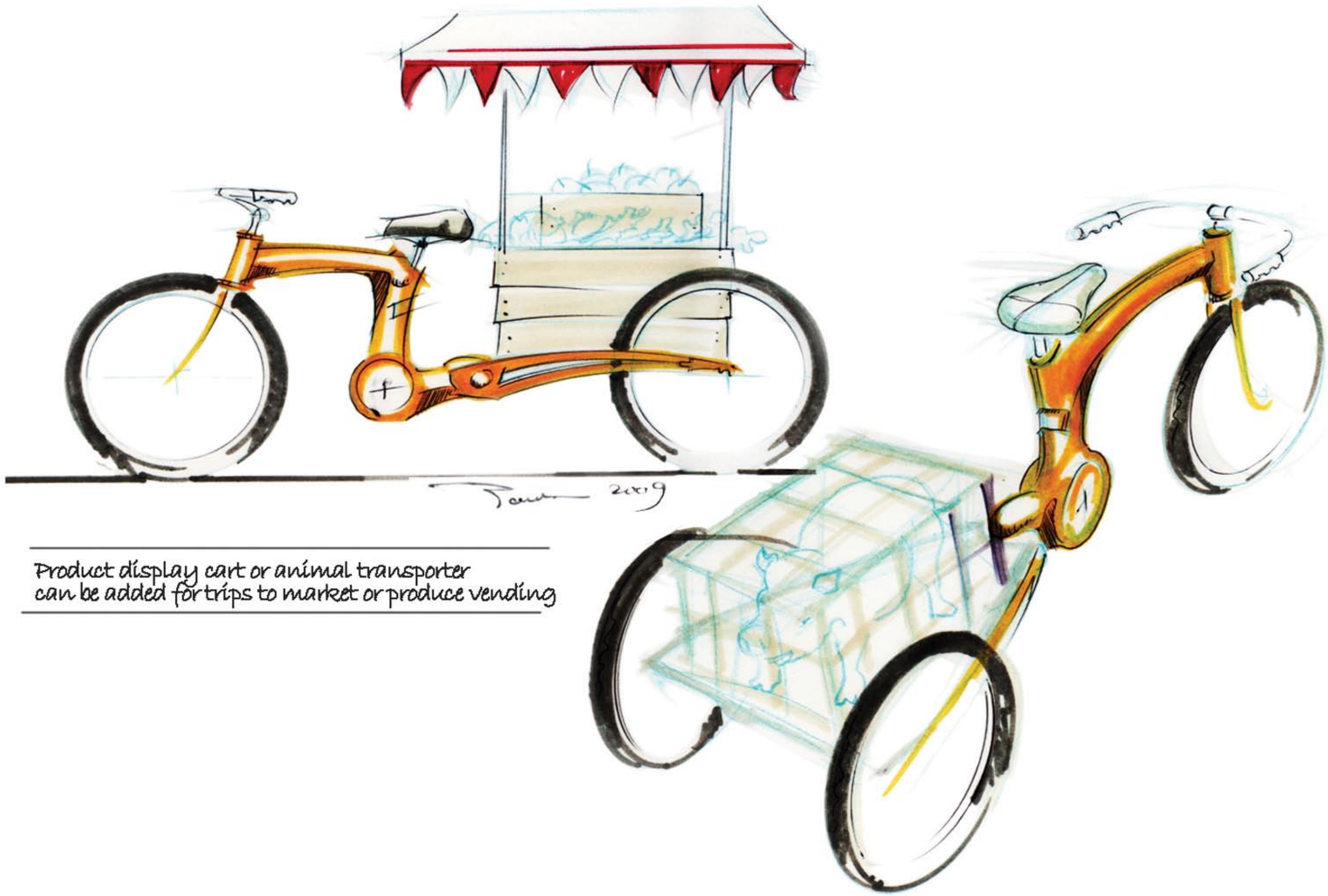


Fig 200. Concept sketch of other possible attachments

5.14.2 3D Generated Images

3D software was used to visualize, simulate and explore the complexity of the form and mechanical parts of this concept idea. This allowed the designer to make any changes and adjustments that were needed on the computer screen prior to building the prototype.

As the two rear wheels can splay apart, the main gear needed to be able to deliver sufficient power to drive each wheel separately in both splayed and closed positions. This idea has been explored and built using CAD software to simulate these mechanical movements. This has made the development of the design possible as to build the actual mechanical parts would be too costly.

The same software was also used to:

Fig 201. CAD rendition of the gearing system of ideal bicycle

1. Explore and create a detachable passenger seat which can also be used as an attachment point or to hook/hang baskets on.

Fig 202. CAD rendition of the multi-function rear seat structure

2. Explore and create the trailer which not only acts as an extension of the loading bay but also functions as a wheel barrow.

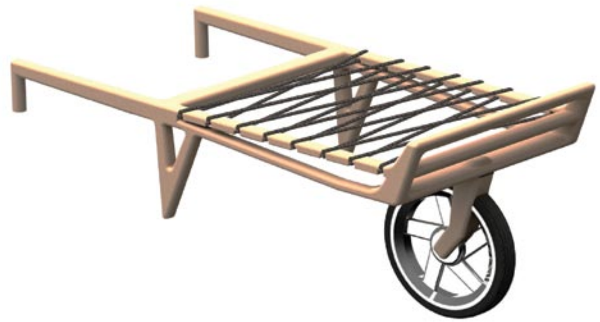


Fig 203. CAD rendition of the multi-function trailer

3. Create a realistic 3D image of the full representation of the proposed idea.

Fig 204. CAD rendition of the ideal bicycle and the multi-function trailer

4. Produce a semi-working scale model which was built to represent this concept idea using rapid prototyping.

5.14.3 Semi-working Scale Model

A scale 1:5 semi-working prototype was created using a rapid prototyping process, to illustrate the operation and functions of the “ideal bicycle” and its accessories.

Fig 205. Rear view of rapid prototype semi-working scale model with rear arms splayed apart

Fig 206. Front view of rapid prototype semi-working scale model with rear with rear arms close together

Fig 207. Rear view of rapid prototype semi-working scale model with rear arms splayed apart

Fig 208. Side view of rapid prototype semi-working scale model with rear with rear arms close together

Fig 209. Front view of rapid prototype semi-working scale model with rear with rear arms close together

Fig 210. Rear View of rapid prototype semi-working scale model of the ideal bicycle with the multi-function trailer

5.15 Design Bicycle Attachment/Accessories

Based on the findings gathered from the previous research methods and expert interviews, and with a focus on the user's needs and wants, this research study also explored ways to customize and increase the functionality of the existing bicycle in Third World countries.

5.15.1 Bicycle attachment concepts

Eleven attachment concept ideas were produced focusing on user's needs, task requirements and the load bearing requirements of the bicycle. All concept ideas were designed so that they could be folded or collapsed when not in use as a carrier so the bicycle could still be operated as transportation to carry loved ones to school or to the market.

Fig 211. Concept 3

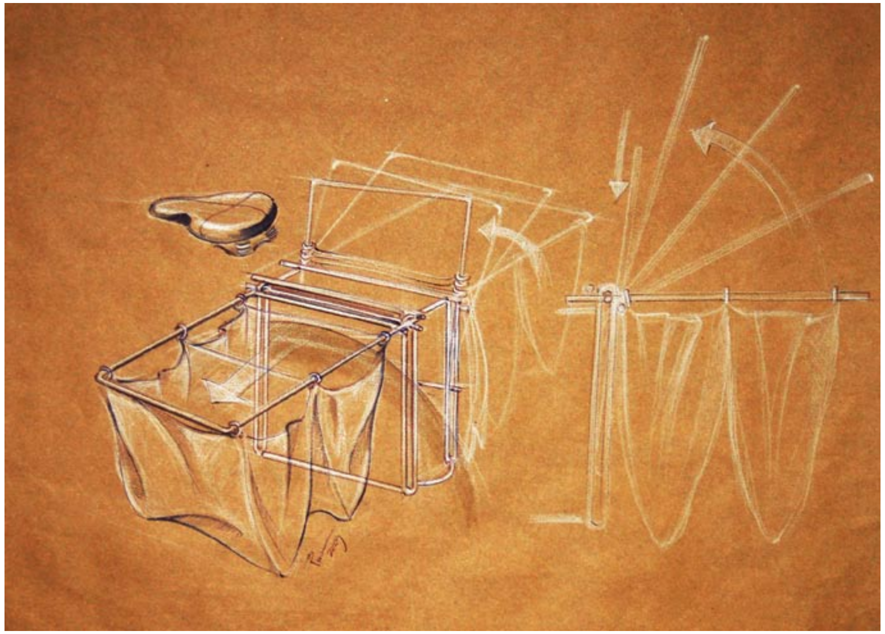


Fig 212. Concept 10

Concepts 3 and 10 were designed to accommodate loads weighing up to 40kg. This would be suitable for fruit pickers or agricultural farmers to carry fruit, vegetables or farm produce.

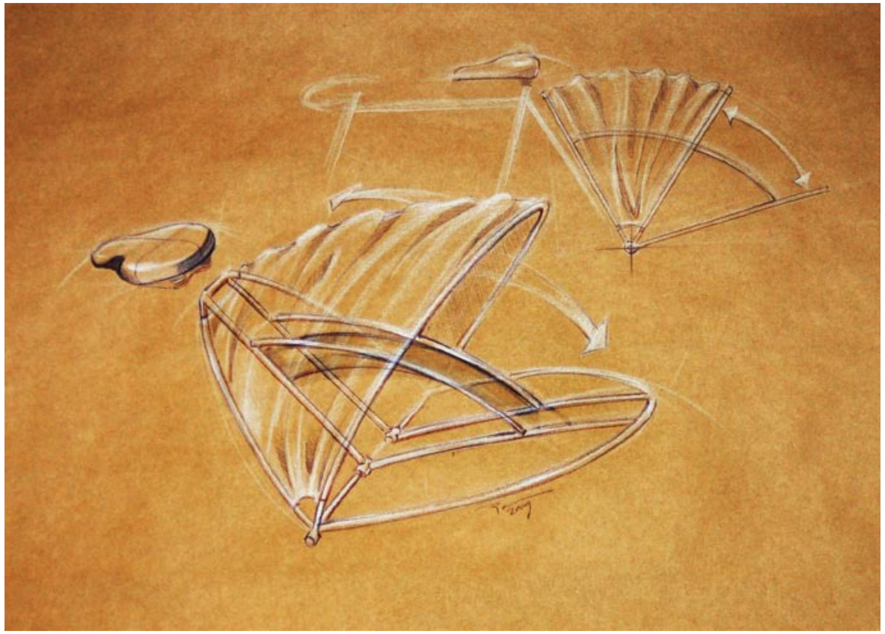


Fig 213. Concept 1

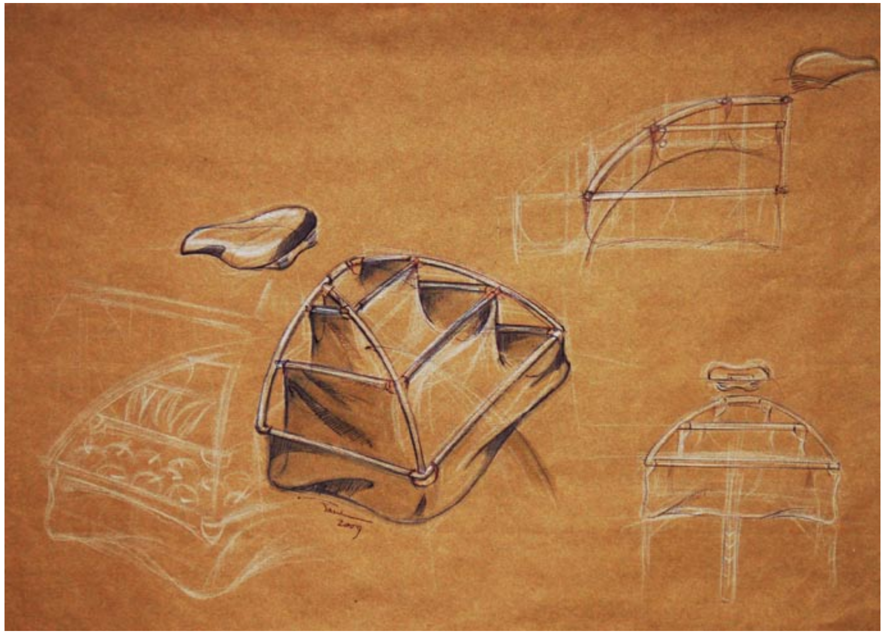


Fig 214. Concept 11

Concepts 1 and 11 incorporated soft materials such as canvas or other natural woven materials like woven flax or bamboo and were designed to carry weights up to 60kg. This would be suitable for a farmer or hawker.

Concept 11 was designed to take into consideration the needs of a fruit or vegetable hawker to display their produce at the market. Concept 1 was designed to give farm produce protection from the heat of the sun and rainy weather.

Concepts 6, 7, 8 and 9 incorporated a soft, strong material like canvas to reduce weight and accommodate load weights up to 80kg. These designs are suitable for farm workers or movers.

Fig 215. Concept 9

Fig 216. Concept 6

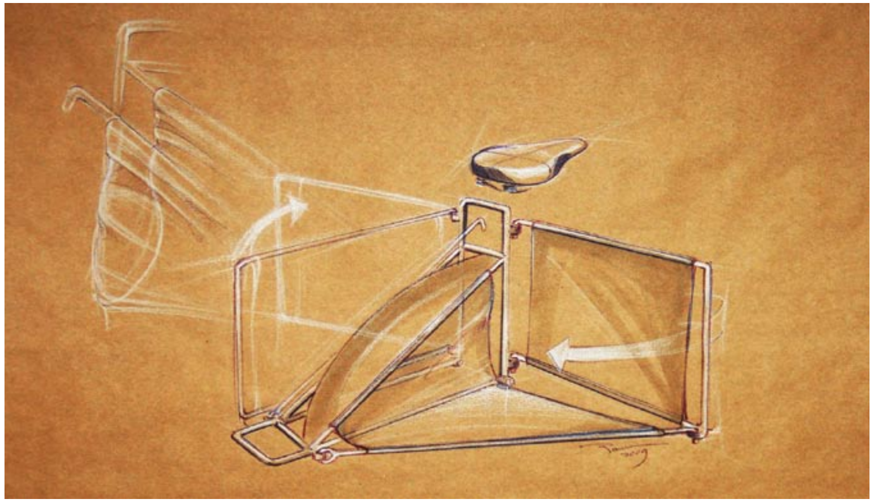


Fig 217. Concept 7

Fig 218. Concept 8

Concept 2 was designed to accommodate load weights up to 100kg and is suitable for carrying rice sacks or farm animals. The rack has a 15 degree incline to distribute weight onto the centre of the rear wheel.

Fig 219. Concept 2

Concepts 4 and 5 was designed to accommodate load weights between 100kg–300kg. Extra wheels are needed to carry these heavier weights and provide additional stability. These designs are suitable for movers or for special tasks.

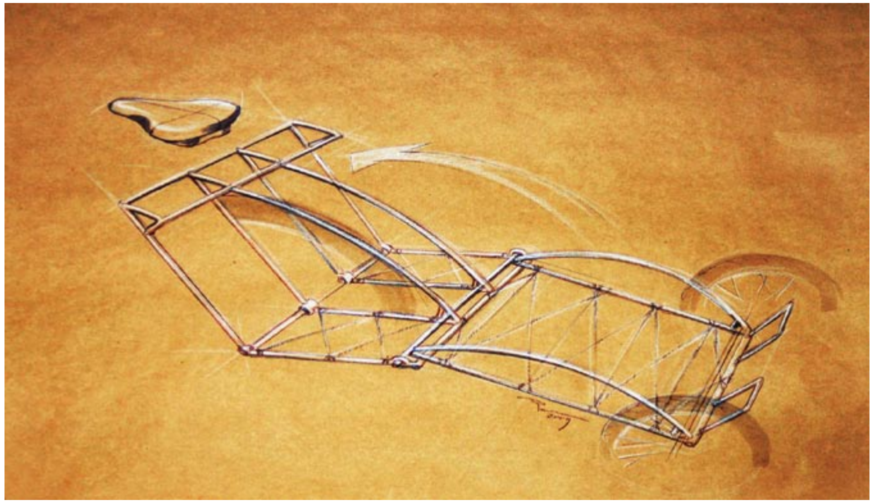


Fig 220.Concept 4

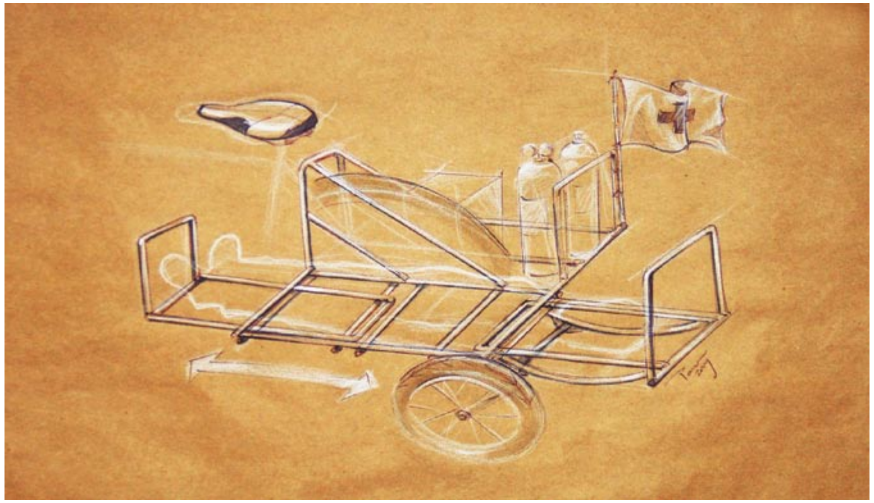


Fig 221. Concept 5

5.15.2 3D semi-working attachment mock ups

Based on the eleven sketches of attachment ideas, semi-working scaled down mock- ups have been created to give the designer better interaction and a greater understanding of the mechanical flow of each system. These 3D mock-ups have provided information on how the mechanism is intended to work, how the structure can be improved and how the whole system can be integrated with existing bicycles in Third World countries. All this would not be possible to achieve with a series of plain 2D drawings only.

Fig 222-232. The 11 mock ups of bicycle attachment ideas

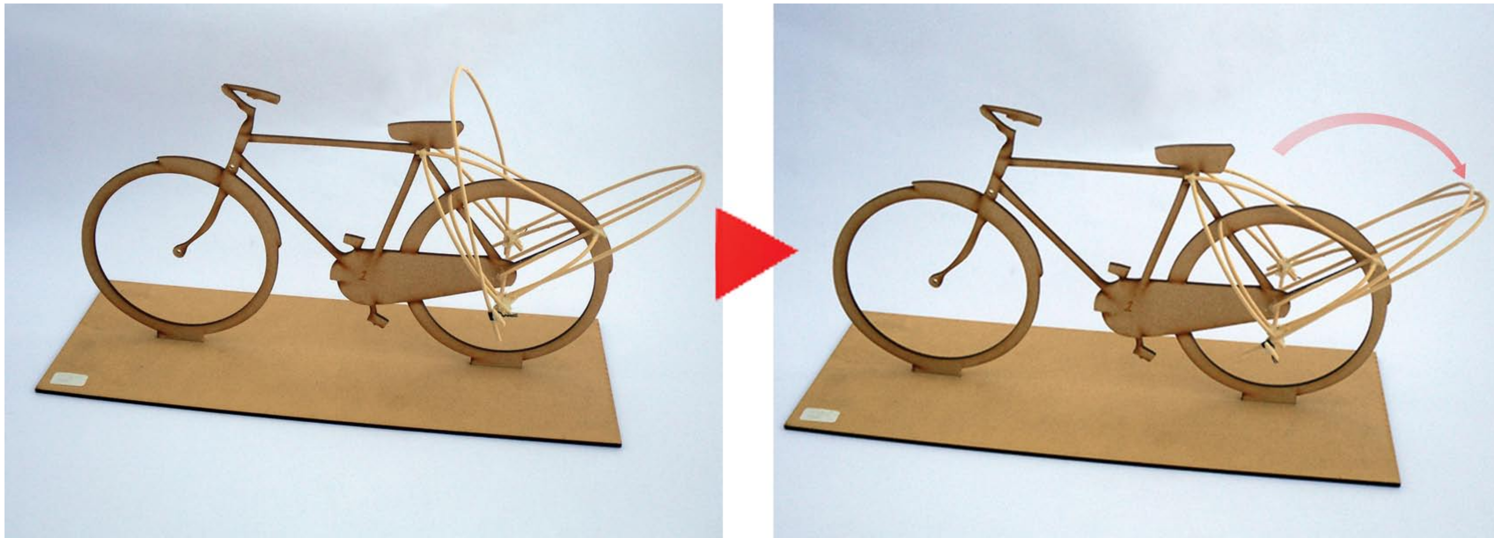


Fig 222. Semi-working scale model of Concept 1

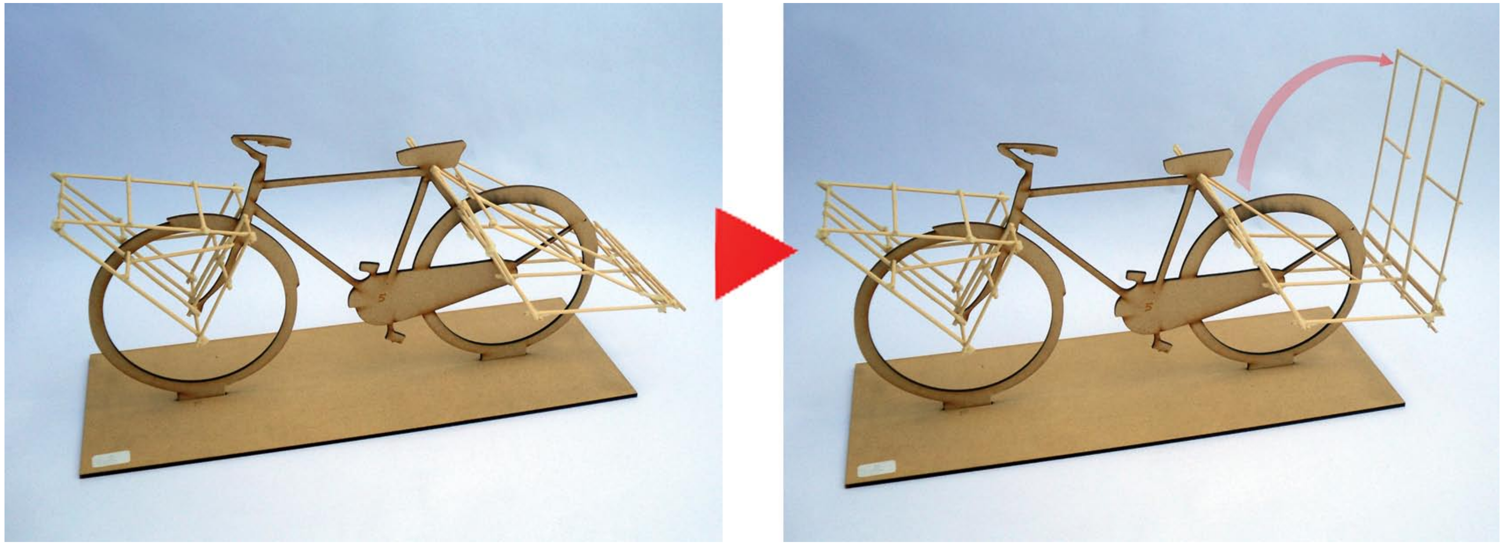


Fig 223. Semi-working scale model of Concept 2

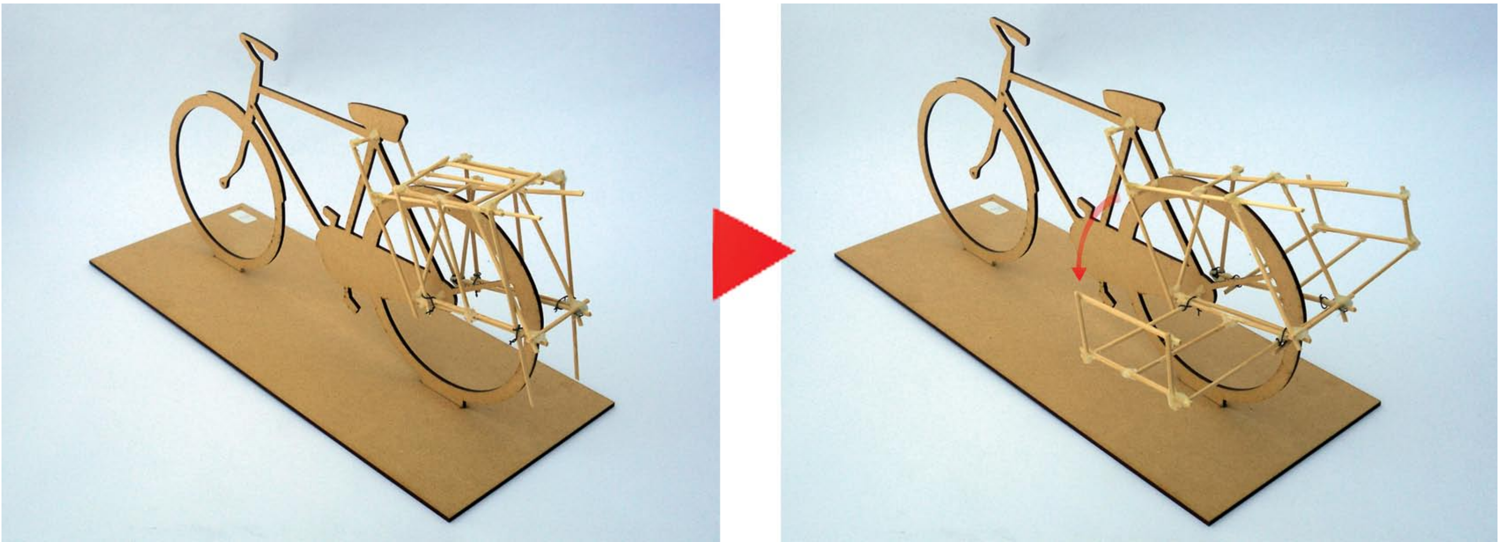


Fig 224. Semi-working scale model of Concept 3

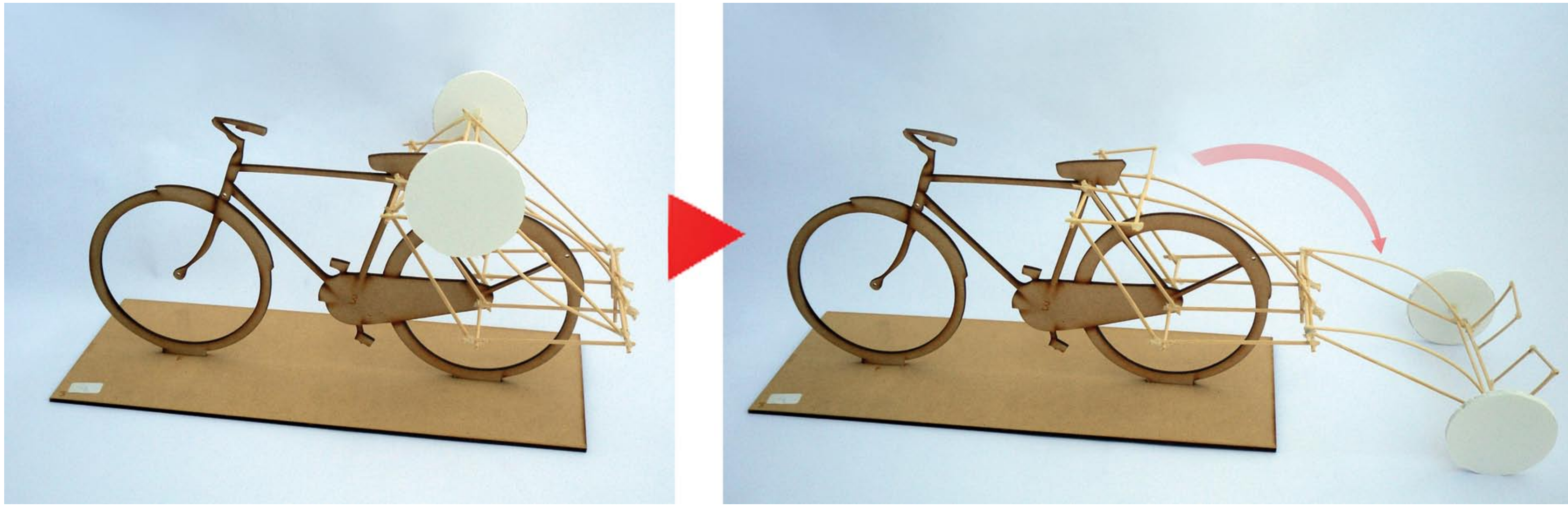


Fig 225. Semi-working scale model of Concept 4

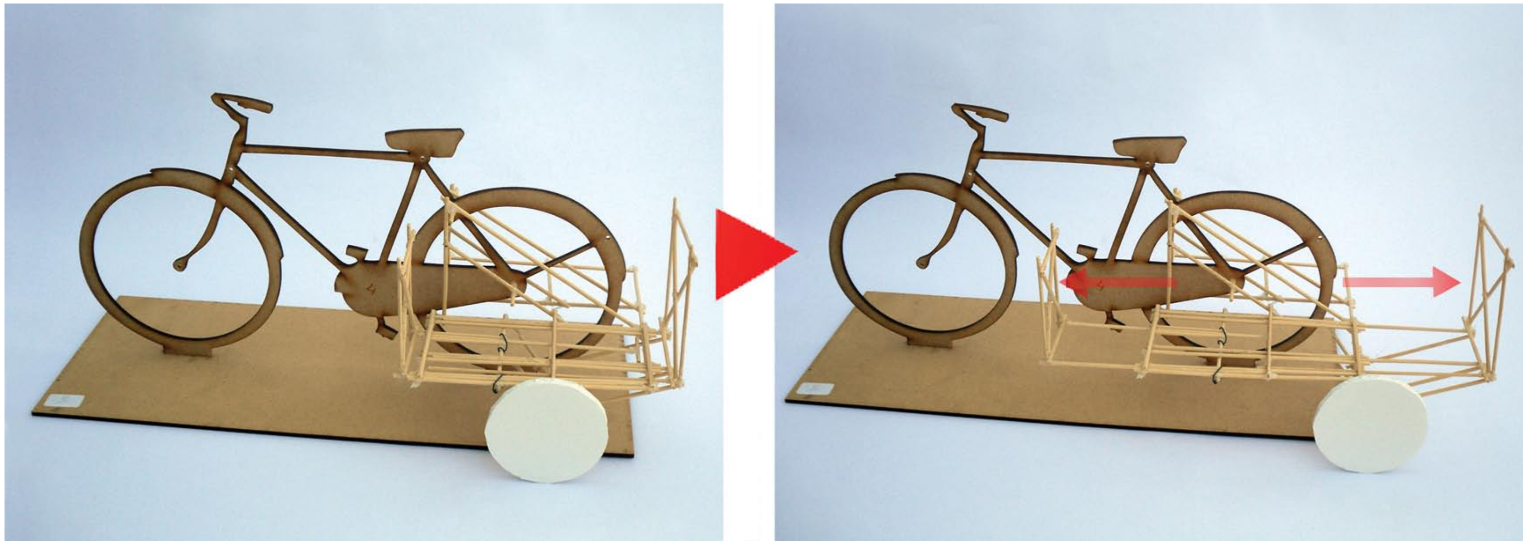


Fig 226. Semi-working scale model of Concept 5

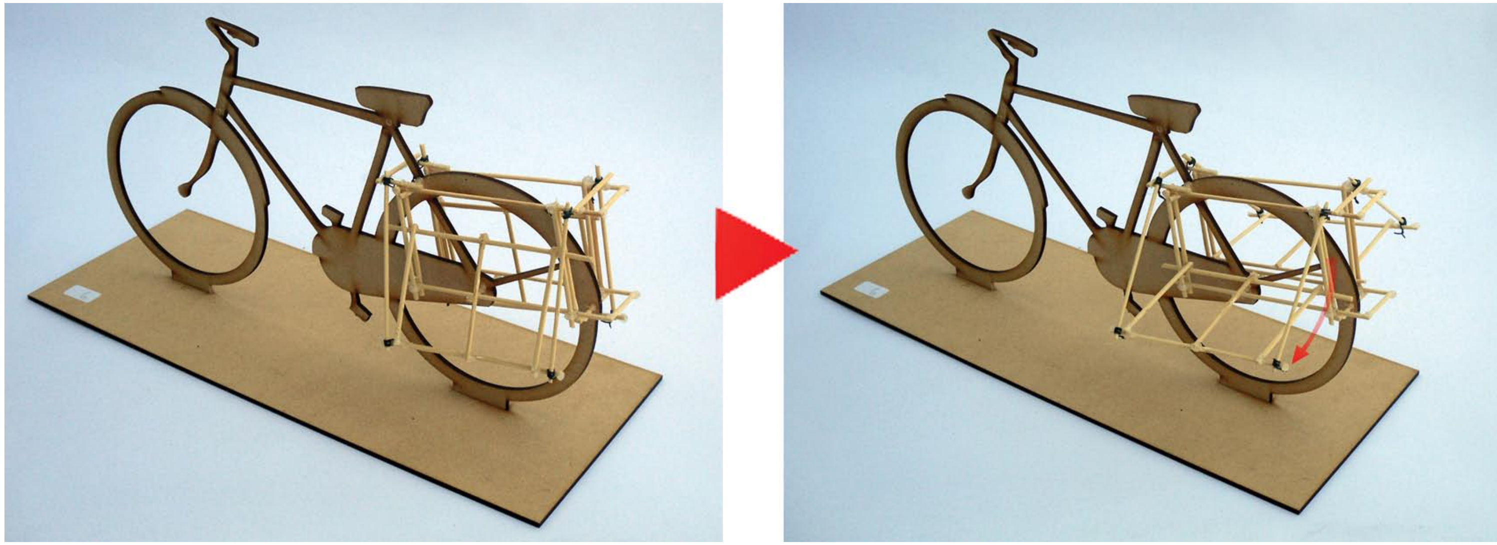


Fig 227. Semi-working scale model of Concept 6

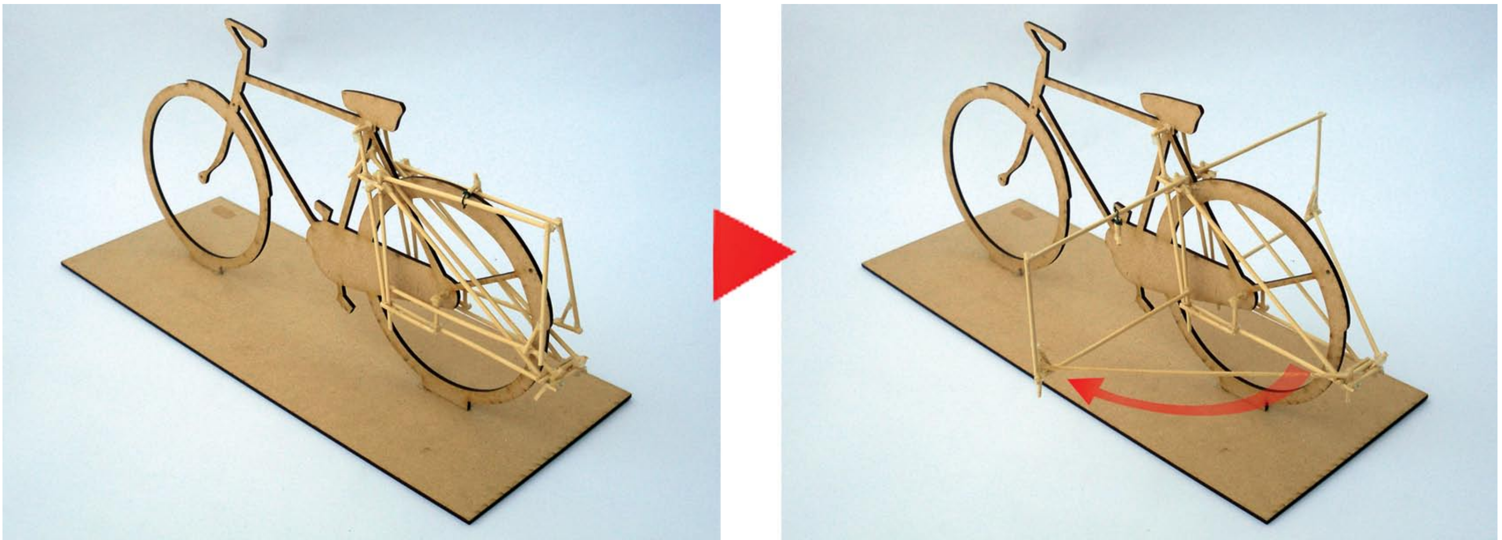


Fig 228. Semi-working scale model of Concept 7

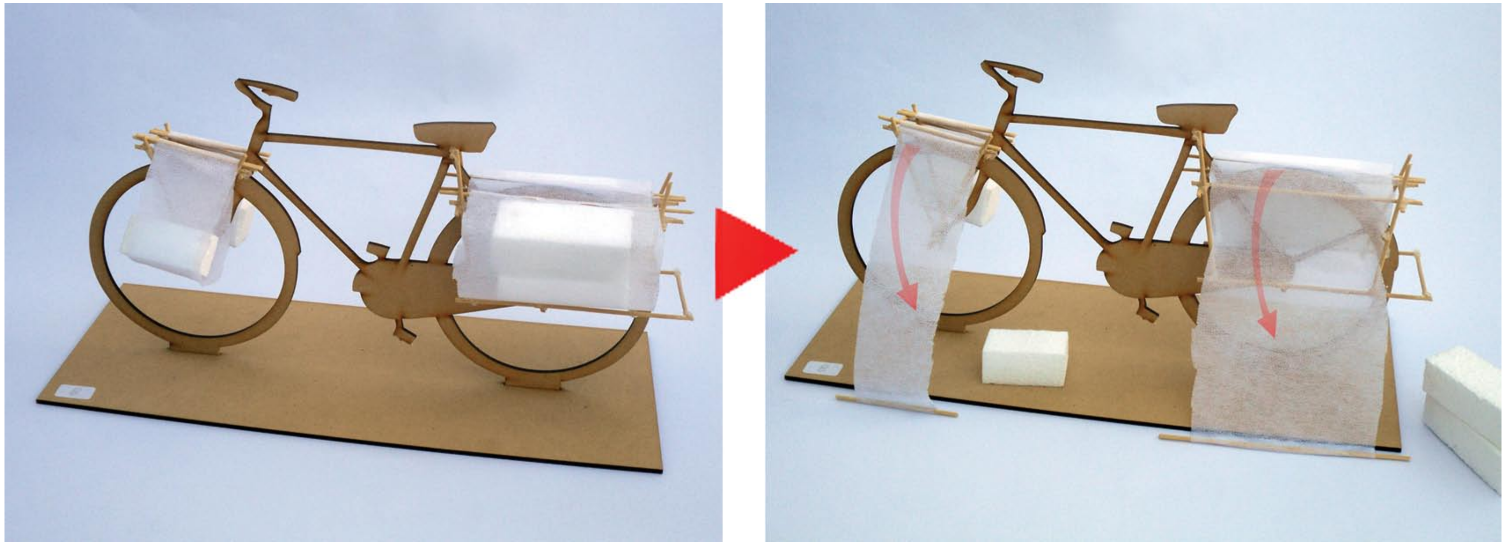


Fig 229. Semi-working scale model of Concept 8

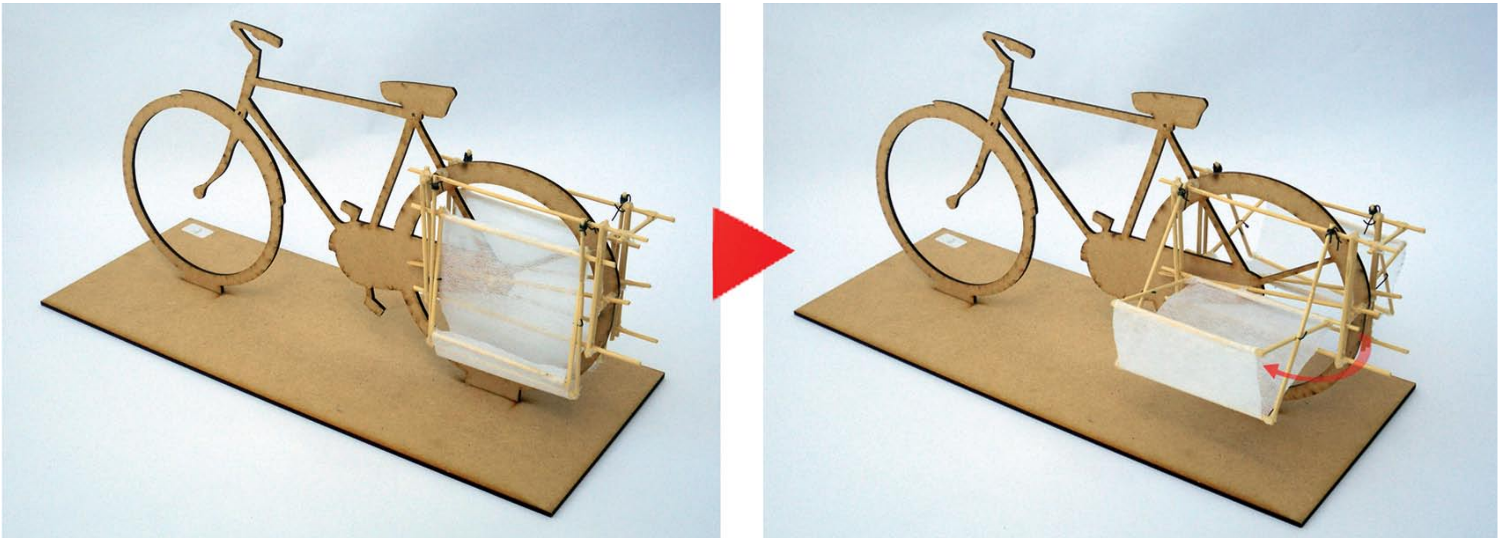


Fig 230. Semi-working scale model of Concept 9

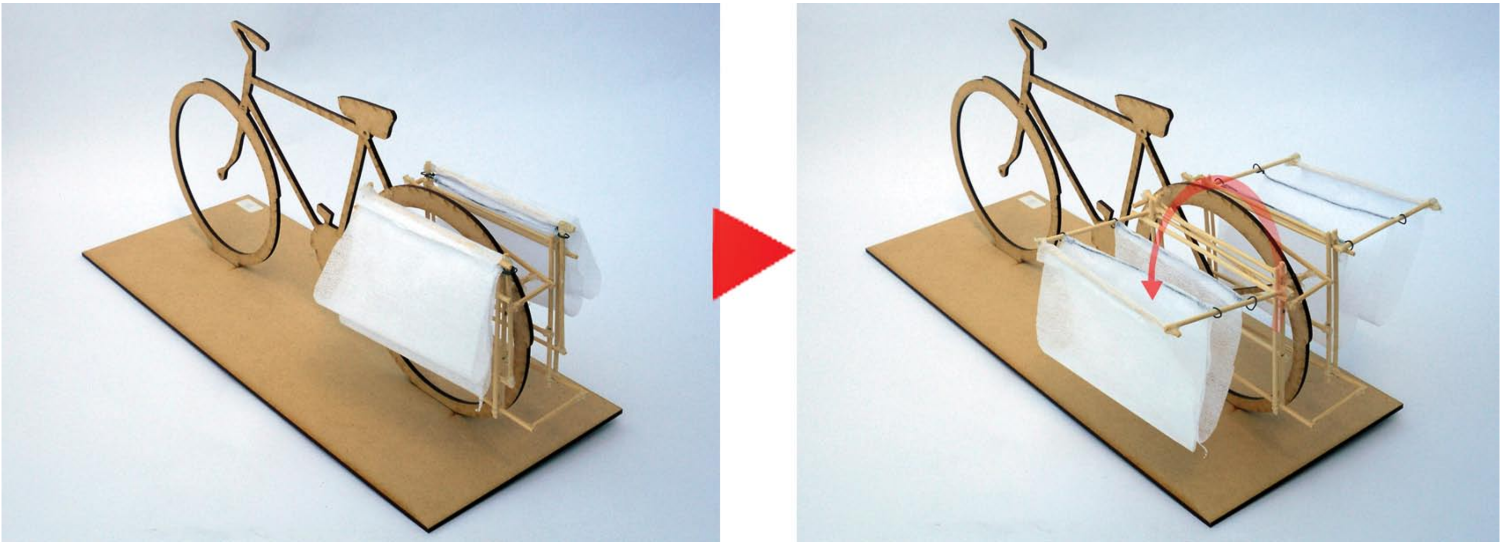


Fig 231. Semi-working scale model of Concept 10

Fig 232. Semi-working scale model of Concept 11

5.15.3 3D generated operational images (Appendix H)

3D software was used to further illustrate, simulate and explore the complexity of the form and mechanical parts of each concept idea in more detail. This allowed the designer to make any improvements and adjustments that were needed to simplify the operation of each system.

5.16 Attachment Option Menu

A poster acted as a tool to introduce locals to new possibilities for bicycle application use to suit their needs. The main objectives for creating this communication tool are:

1. To allow target users to develop and manufacture the attachment based on local skills and expertise using available raw materials.
2. To give the user freedom to use materials that suits the use purpose, their budget and technical expertise.
3. To eliminate any bias or preconceived ideas by the designer. This gives the target users the ability to customize and personalize the attachment based on their real needs rather than the designer's perception of their needs and wants.

5.16.1 Proposed Poster Layout

A proposed A1 size poster has been designed featuring ideas of the different bicycle attachments and their potential uses. This main poster would be put on display at the village co-operative and works as a menu of ideas for the target users to choose from based on their needs.

A proposed A4 size pamphlet was designed to show more detail of each idea including component

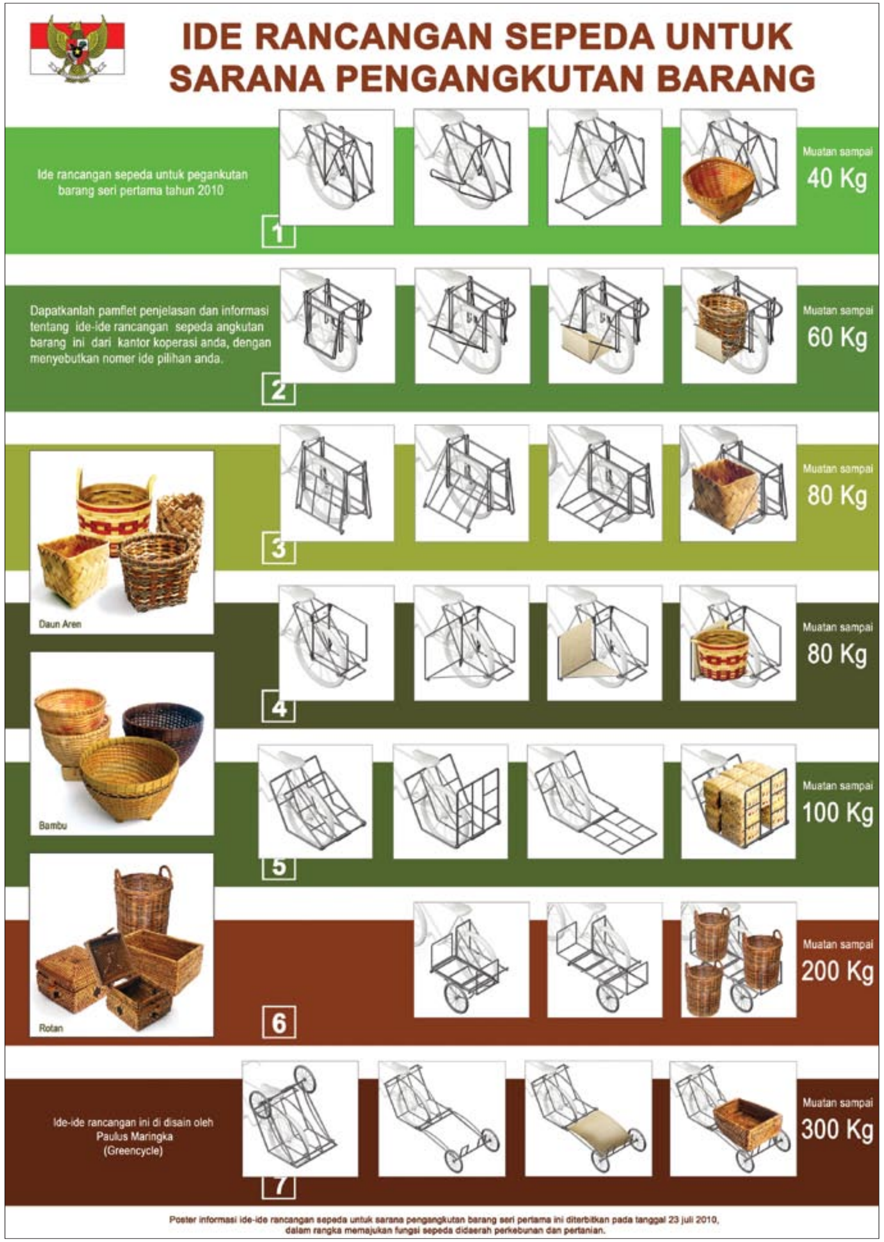


Fig 233. Sample of proposed A1 Poster Menu

drawings with proposed dimensions, based on the older bicycle model which is commonly used by target users as a work horse. All the designs on the menu can be attached to either the plate located under the bicycle seat (on existing old bicycles or Greencycle) or the rear wheel axle.

It was crucial that the poster design used simple colour coded visual images and was in the local language so that it was easy to understand (many of the target users illiterate).

5.16.2 Proposed Pamphlet Layout

This A4 size pamphlet will be distributed to any target user who is interested in a specific idea on the poster. The pamphlet will only contain basic information, using simple visual language so it can be easily understood by the target user. The idea of this pamphlet is to provide a basic framework of suggestions/ideas to encourage the target user to adopt and produce their own attachment based on their individual needs and affordability while promoting local craft businesses to generate an income.

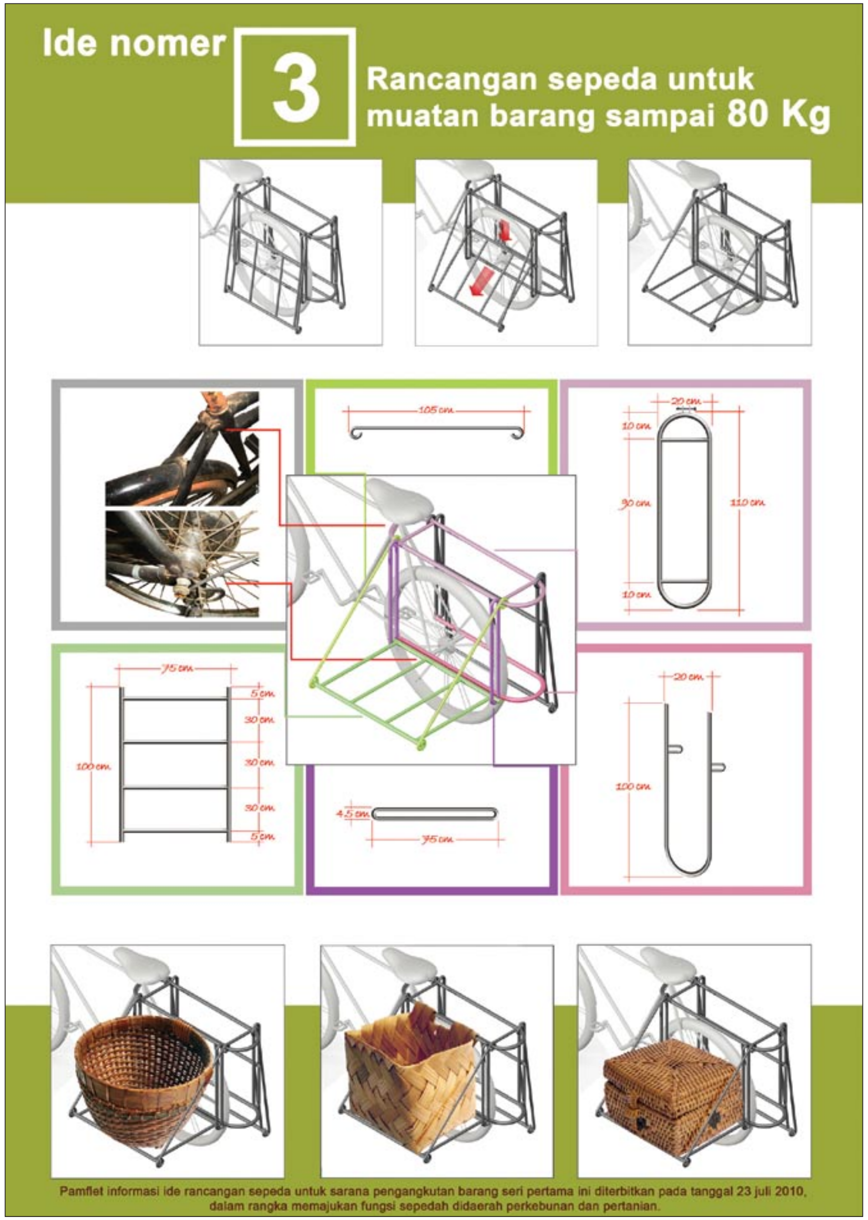


Fig 234. Sample of proposed A4 Pamphlet

The evaluation process consisted of four phases:

Phase 1: Focus group/Brainstorming
Phase 2: Expert Interviews
Phase 3: Visits to Indonesia
Phase 4: User testing

6.1 Focus Group/Brainstorming

Three focus groups have been used for brainstorming and to evaluate the Greencycle and accessories. This is a group activity technique to generate a large number of ideas for the solution to a problem. Originally developed by Alex Faickney Osborn in 1953 as a tool to support fact, idea and solution finding, brainstorming is based on two principles:

- Delayed judgment – it is essential in a brainstorming session to be able to suspend judgment and focus on the ideation.
- Quantity breeds quality – taking the view that the best way to find a good idea is to generate lots of ideas, which can be combined, built on and developed.

Three groups of participants were invited to separate brainstorming sessions: six undergraduate design students, four post-graduate design students and four recent graduate design students who currently work in the design industry. These groupings were to prevent hierarchy issues and to eliminate production blocking or social loafing and evaluation apprehension.

Each participant was then asked to express their thoughts by drawing simple sketches to illustrate their idea. This method works to prevent production blocking and is also useful in encouraging or allowing each participant to present their idea. These sketches were then collected, analyzed and used to give an insight for the next design phase.

Fig 235. Brainstorming session

To ensure all ideas were captured and displayed visually, six designs of bicycle accessories or extensions were presented in the form of working concept models focusing on systems that can be attached to a bicycle to enable the user to carry heavy loads with ease and safety. Each model was supported by sketches to describe its functionality in more detail.

Before a brainstorming session, it is critical to define the issues. The issues must be clear and not too big and captured as a specific question. Three focus questions were presented to each group:

1. Are there any obvious issues with any of these ideas/systems?
2. Can any of these ideas/systems be improved on or simplified?
3. Can each design be attached to the bicycle to enable the user to carry heavy loads easily and safely?

Although some researchers think that traditional brainstorming does not increase the productivity of groups as described in Rickards (1999), it still provided benefits to this research project as all three groups provided different but equally important insights at this point in the design process.

6.1.1 The first group (undergraduate students) went straight to drawing a new system or tried to come up with all the different systems that they could think of. The result was a few raw ideas but nevertheless useful enough as they provided a new perspective on

Fig 236. Brainstorming session

these issues. They did not necessarily understand the fundamental issues with the design but came up with new systems without restriction which allowed them to generate new ideas that had not been explored.

6.1.2 The second group (post-graduate students) provided this research project with new and useful solutions. They thought through the issues, resolved problems and came up with a couple of good solutions. Even though the solutions were not perfect they were easily understood and capable of being modified to suit the needs of this research project.

6.1.3 The third group (design practitioners) also provided aspects to be explored. This group was more interested in understanding the background information of the project and presented questions regarding usability, functionality and the historical background of the project. They wanted to know the reasons behind these designs. These questions helped force the researcher to think more about this project, like how the project could be useful to the users and what is the best way to improve the function of the bicycle for the user target demographic.

6.2 Expert Interviews

Expert interviews are a way of making tacit knowledge more explicit. An expert is someone considered a leader in a particular subject, program, process, policy, etc. An expert

Fig 237. Expert interview 1

can describe not only what was done but why, providing context and explaining the judgment behind the action. This information gathering method is difficult to explore by any other method as it is only accessible by way of the expert and their particular area of expertise. This method is also less problematic than methods where the influencing of others could affect outcomes. However, this method can be disadvantaged when an expert is withholding information or avoiding certain topics. (Van Audenhove, 2007)

Three experts were selected based on their experience and specific knowledge from the Designers' Institute of New Zealand members list to validate, challenge and identify gaps or areas of concern that needed addressing, These experts were: an industrial designer/engineer, an Industrial designer research and developer and a former European motorcycle designer. The different backgrounds of the expert interviewees provided a good overview and detailed knowledge on this subject. Each session format was conducted as an informal one-on-one meeting and the topic list varied according to the expertise of the interviewee. This method had the advantage of generating high level discussion and information generation, and detailed explanation of motives and orientation. However, interpreting interaction effects was part of the data production.

With preliminary sketches and mock-ups on hand, expert feedback was used to challenge/validate all assumptions against the vision and the user research. Based on the expert responses, the researcher was able to iteratively refine the design, simplify the systems, revisit the user needs and wants and ultimately develop functional design specifications and success metrics for the development stage.

Through an analysis of case studies, personas, scenario building and expert interviews, the proposed products' functionality and usability were documented, with gaps identified and areas of concern addressed. The data gathered has been used to inform the idea development process and the final idea.

Fig 238. Expert interview 2

Fig 239. Expert interview 3

Fig 240. Old push cart in the middle of a padi field at Sukamakmur

6.3 Visiting Indonesia

The population of Indonesia has grown at an average annual rate of around 1.8 per cent for the last twenty years. This growth rate is higher than in most other developing countries, especially in the Asian region. In 2005, the population of Indonesia had reached around 226 million people. (United Nations Department of Economic and Social Affairs, 2007)

This population growth has resulted in a significant increase in food demand, however the availability of agricultural land has become a constraint and rice production growth has slowed since the mid-1990s. As a result, Indonesia's government has pursued policies that encourage agricultural production and provide protection to farmers. This includes both tariff and non-tariff protection, particualrly import regulations. This has helped to slow the growth of the farming culture not only in rice production but also wheat based products, fruit and live stock products including beef and dairy products. (Suryahadi, et al., 2006)

Rising populations in major Indonesian cities have forced the farming industry further out to the city outskirts which has increased the cost of transporting goods to and from local markets. With agriculture remaining an important source of income for most of the population in the lower income bracket, these two aspects have highlighted the need for functional, affordable land based intermediate means of transportation in Indonesia and other similar developing countries. Villages such as Sukamakmur, whose population lives mostly from farming, bicycle use remains the main form of transportation available in this area. Therefore, they are an ideal target group for prototype testing.

Based on insights gathered from the expert interviews, three scale working mock-ups and nine 2D images from the first eleven concepts were presented to the target users at Sukamakmur Village in order to collect feedback. Initially it was hoped that one out of five developed trailer ideas would be built for prototype testing. Other support images were also included and used as visual aids for presentation to the target user. This was simply to avoid alienation of any participant as illiteracy is a common issue within the targeted group.

The aim for this prototype testing was not only to test the design principle before introducing the real material (bamboo) into the design but also to see if the target user was willing to accept and embrace new ideas. Feedback and insights gathered from this prototype testing was used to explore and develop the final ideas.

Initially five full-scale trailers of the developed idea were to be built and distributed to framers at Sukamakmur. Due to time constraints, only two managed to be built and distributed. Applying a user centred design approach, the two trailers were built using two different materials and methods. This provided valuable information about local manufacturing skills and gave a more accurate projection of cost and the issues and challenges likely to arise in the manufacturing process for the target user.

6.3.1 Trailer Prototype 1

The first trailer was built by a local blacksmith on the outskirts of the city using traditional gas torch welding methods which dictated material choice. Supplied with a working drawing of the prototype, certain freedoms were given to the blacksmith to use their own interpretation on how the prototype was supposed to be built. This was to provide a better understanding of the locals' skill and knowledge. This blacksmith was chosen based on their close proximity to the target demographic. This gave the designer a

Fig 241. Trailer prototype no. 1

better understanding and more realistic view of the manufacturing process in situ.

Due to this relatively simple technology, construction steel rod was chosen to be the ideal material. This material is not only cheap but also enabled the black smith to manipulate and form the steel rod very easily after heating it up. However, this material choice caused a breakdown in structural integrity when placed under heavy weight pressure, therefore additional steel rods needed to be added to reinforce the frame to prevent it from bending. Even though more steel rod pieces were needed to make the prototype frame sturdy, the overall weight of the unit was lighter than the second prototype which was made of tubular steel.

To simplify the process, the blacksmith suggested using a ready-made part from a BMX bicycle (called a peg) which was available locally for only 20.000 rupiahs (NZ$3.50). This aluminum peg simply screwed directly onto the rear axle and became an extension to provide an attachment point for the trailer. This quickly resolved an issue which had been problematic at the testing stage. When weight was first put onto the trailer, the peg broke off the axel because there wasn't enough thread to secure it and when turning, the weight on the trailer forced the rear wheel to move from side to side from the axis point. In the end, this part was replaced by a specially made part as originally designed.

Fig 242. Existing "peg" used as an attachment bracket

This first prototype took almost a full week to build, including all the changes and modifications made along the way. The cost of materials and labour added up to 800.000 rupiah (NZ$130).

A test was done on the trailer's completion using a modern mountain bike. Without a load the trailer was pulled along without any problems. It was anticipated the cornering would need a little getting used to as it wasn't designed to go around sharp corners. The bike with trailer was then tested and ridden by some locals, again without problems. Unlike a two-wheel

Fig 243. Trailer testing with a 100kg load

trailer, this one-wheel trailer traveled smoothly and almost undetectably as there was no rocking from side to side from the uneven road surface as a two-wheeler would. The only movement on this trailer is the up and down movement which is hardly noticeable by the rider as the connection point works as a pivot without upsetting the balance of the bicycle.

As weight was applied to the trailer, the difficulty of riding the bicycle while loaded became more apparent. As the trailer acts as an extension of the bicycle frame, it is trickier to balance the bicycle moving forward from a standing-still position. It was like holding up a thin bamboo stick with a weight attached at the opposite end – the longer the stick, the harder it is to keep it up and steady. With a 50kg load on the trailer it was still relatively manageable to ride the bicycle but with a 100kg load the bicycle became really difficult to keep balanced. While the joining bracket had been resolved from the earlier problem, the pressure of the load transferred directly onto the rear wheel, resulting in its collapse.

Fig 244. Broken bracket

This experiment brought about a significant observation. Modern bicycles, with their light frames and small wheel diameters, are ill-equipped to withstand heavy loads whereas old bicycles, with their large frames and wheel diameters, are designed to be the work horses that the target users require them to be.

6.3.2 Old Bicycles

The failure of the modern bicycle on the test run made the purchasing of an old bicycle necessary. To produce a true result from testing the finished prototype, the trailer and its load needed to be tested on an old bicycle design for which the trailer was intended. Even though older bicycles are still commonly used as an intermediate means of transport on the outskirts of Jakarta, to actually find one for sale wasn't an easy task. Most of these bicycles have become collector's items and they are now expensive to buy and are valued as a luxury item. There are even clubs for the owners of these old bicycles, which is becoming a real trend in Indonesia.

Efforts were made to find one of these bicycles at several secondhand markets around Jakarta but it was soon realized that all these bicycles are in current use. Because of the quality of these old bicycles, it has made them popular and sought after by the target user. The only old bicycles that could be found in Jakarta are the ones being used as work horses and these are not for sale. Information was obtained through a bicycle enthusiast club on where these old bicycles could be purchased. On the outskirts of Jakarta, in an area called Ciledug, several of these old bicycles were offered for sale along the street with an asking price from 800.000 to 4.500.000 rupiahs (NZ$150-$750). The bicycles on offer were all made in England; they were a 1940s Phillips cycle made in Birmingham, a 1950s Raleigh made in Nottingham, a 1940s Royal ladies bicycle and a 1950s Hercules cycle made in Birmingham, along with two other

Fig 245. 1950s bicycle made in Birmingham

unidentified bicycles. Most of these bicycles were incomplete and many of the parts had been replaced with locally manufactured parts. After spending half an hour negotiating on the price, the 1950s Hercules cycle was purchased for NZ$100. This price tag emphasizes how precious this type of bicycle is to the target users

For low income bicycle users, the decision to own one of these cycles is a difficult one – it comes with a high purchase price due to their rarity and many are incomplete so further costs will be incurred to get it into a reasonable working condition. For someone who only makes around NZ$10 a day, this is a huge sacrifice to make as their entire livelihood depends on it. However, case studies have pointed out that the target user is willing to pay the cost as they see it as a good investment. These case studies noted that the only regular maintenance the users have to make for these older bicycles is to purchase new tyres when the existing ones wear out.

Fig 246. 1950s Hercules cycle made in Birmingham

6.3.3 Trailer Prototype 2

The second prototype was made based on the original working drawing done by the designer and the lessons gained from making Prototype 1 to avoid any unnecessary time wasting. A decision was made to use contemporary technology to build Prototype 2 to give a comparison in cost and quality of the two finished prototypes. With the advantage of more advanced technology, Prototype 2 was made to be sturdier and stronger using fewer parts with heavier gauge tubular steel.

Using the old style bicycle, all necessary measurements were done reasonably accurately. This prototype turned out to be much sturdier and used fewer parts but weighed slightly more than Prototype 1. Using the skills of highly trained craftsman and proper equipment, prototype two was completed in 12 hours. However, this was only achieved under strict supervision from the researcher/designer after a mistake was made which resulted in deconstructing the frame, even though specific instructions were given to avoid it. The total cost of prototype two was 500.000 rupiah (NZ$83). This cost was not a true reflection of the real cost as the engineering workshop was owned by an acquaintance of the researcher.

Testing was done at the workshop by various people with and without a load and it was also tested by carrying a passenger on the trailer. All tests on Prototype 2 went smoothly.

Fig 247-249. Working on Prototype 2

Fig 247

Fig 248

Fig 249

6.3.4 Trailer Wheels

More testing was done by the researcher and other locals after the completion of these prototypes from the structural and operational aspects. This was to ensure the quality of the prototypes prior to user testing. New larger wheels and tyres (26”) were placed on the trailer which was loaded with a 60kg weight while riding on a rough surfaced road because this wasn’t done previously. This testing proved the new wheel couldn’t withstand the weight and simply gave way. Even though the wheels and tyres were new, it was clear they weren’t made for a working bicycle.

Most modern wheels for modern bicycles are made of

Fig 250. Buckled modern aluminum wheel after testing

Fig 251. Special wheel and tyre

Fig 252. Testing the wheel and tyre

aluminum to reduce the entire weight of the bicycle. As a trade off, they aren’t as strong as old bicycle wheels which are made of steel. Moreover, unlike the two-wheel trailer, where the load is shared evenly on both tyres, a single wheel needs to carry the entire load. These prototypes were initially designed to fit any wheel size; however these tests have highlighted the importance of having the right wheel to ensure the prototype is operating correctly.

A special wheel, originally manufactured for ’becak’ use, was highly recommended by the target users who supplied the researcher with an address to source it from. It measures 28” in diameter and is unmistakably branded with “becak barang” (becak trailer) on the tyre. With the correct wheel now fitted, the last test was conducted with two adults jumping up and down on the trailer to simulate extreme conditions. The “becak barang” wheel passed the test with flying colours the night before user testing.

6.3.5 User Testing

As only two prototypes were built due to time constraints, it was important to ensure these prototypes were tested by the right target users. In mid-January 2010 it was decided to visit two separate farming villages to test the prototype in the same province of West Java: Sukamakmur Village at Karawang, where the initial observation was conducted and Leuwiliang Village, which is located around 77km outside Jakarta and has a landmass of 1.904.569 km2 mostly used as farmland.

The two villages were chosen not only for their similarity in population size and landmass but also for their agricultural background. The date and time of the visit was set and agreed on by local contacts. The local contacts were notified a month prior to the visitation day and were told about the nature of the project and the reason for the visit. The local contacts not only acted as guides but also worked to support the researcher when there were communication challenges (often the target group spoke in their own local dialect).

On arrival at Leuwiliang on 6 January 2010 it was observed that the geography was slightly different to Karawang. As it is located near mountains, this is a cultivated hilly area. The farmers formed their land into multiple terraces to prevent rapid erosion from water irrigation. These levelled sections of land

Fig 253. Terrace padi field

Fig 254. Interview at Leuwiliang

have a stepped appearance and make good use of otherwise unusable sloping land. (Touropia, 2009)

However, a conscious decision was made earlier to visit a village located at the bottom of the mountain which had flatter farmland. When locals were asked about local use of bicycles, they said no one in the area used one. All farm produce is transported by motorcycle at harvest time. With slight embarrassment, the framers interviewed said they didn't even know how to ride a bicycle as they were not commonly used in the area. When asked if this was due to the areas

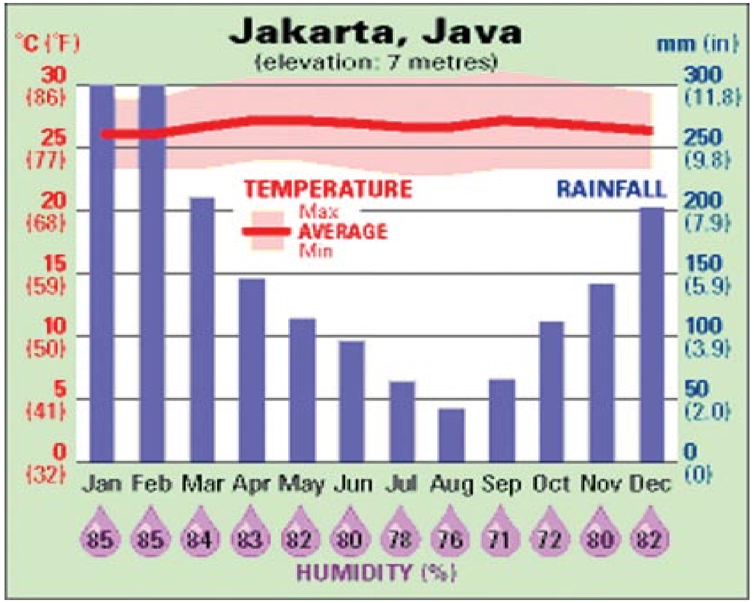


Fig 255.Diagram showing rainfall seasons in Jakarta

Fig 256 Scene after the storm

Fig 257. Scene after the storm

geography, they couldn't give any answer but said as far as they could remember, there is no record of anyone in the area owning a bicycle. This was something the researcher had not counted on, even though the local contact fully understood the purpose of this visit. This issue has highlighted the importance of having first hand local knowledge and not putting to much emphasis in second hand information. Due to the time limitations of the Indonesian visit, this issue had been unforeseen but never the less it has provided a valuable lesson for future work.

Weather was another element that was hard to predict. Even though the journey started under the blistering sun, the weather changed in a matter of minutes. Rainstorms occur all year round in Indonesia, but monsoons bring the heaviest rain in January and February. (Columbus Travel Media Ltd, 2010)

A heavy storm and heavy traffic made the trip to Karawang even slower than it normally would take. The researcher arrived at Karawang just after five in the afternoon and the rain had started to ease by then. There were no signs of anyone working at their farms anymore and grey gloom and water had replaced the lush greenness of the padi fields seen on an earlier observation visit.

6.3.6 Interviews

Interviews were conducted at the village at sunset. Three scale mock-ups, and images of the eleven different bicycle attachment ideas and two trailer ideas were presented to the target group. Five questions were presented to the target user at Sukamakmur.

6.3.6.1 Do the proposed design ideas give you the functionality and usability you need as a farmer?

The answers were yes. Most of the locals were only too eager to give an opinion on who could benefit from each design. Most of them thought the proposed designs were more suitable for fruit or vegetable farmers. Perhaps they couldn't see or didn't understand enough about the potential use in other areas because most participants lived from the land.

6.3.6.2 What do you think of bamboo as a material for a bicycle?

They liked the idea of using this material. Bamboo is a common material to most of them which has been used for many different applications such as building materials, furniture, hats, etc. Not only is bamboo

Figs. 258. & 259. Bamboo used as a bicycle extension by a local

Figs. 259.

readily accessible, it's also economical. One of the locals proudly showed off his 1960s made in China bicycle "Butterfly" which has been modified to transport furniture (bamboo chairs). The bicycle has a simple extension made of two pieces of bamboo which were simply tied down using tyre inner tubes to the bicycle rear seat to provide a longer platform. He works as a delivery person for some of the craftsmen who make bamboo furniture in a neighboring village. He then explained how he puts two chairs one on top of the other which are then tied onto the bamboo platform. He said he can only carry two chairs at a time because otherwise they become too high and unsafe to negotiate the main road traffic to the market. The passing buses, trucks and other big vehicles could easily blow the bicycle off balance due to being heavily loaded. However, this issue could be easily resolved by lowering the platform to stabilize the bicycle ride and by providing a platform on each side of the bicycle which could double the number of chairs he could transport thus saving travelling time.

6.3.6.3 Do you think that customization or modularization will improve your needs?

They all thought there was real merit to having a system that could be customized to their different needs. However they thought they had the solutions in their hands already to enable them to do their job. They were also concerned about the cost of such a system. The proposed idea may offer a positive solution on the cost issue by exploring the use of economical materials such as bamboo as the main material which the target user is already familiar with.

6.3.6.4 Does the look of the proposed design ideas appeal to you?

Most participants liked the look of the proposed design; this is partly due to the aesthetic appeal never having been part of the considerations for local modifications before. Perhaps there is a real opportunity to encourage target users to adopt the proposed design ideas by considering the visual aspect of the idea based on target user perception. This can be used as an ongoing iterative design process between the designer and target users to produce future new ideas.

6.3.6.5 Are there any ideas that you can see from the prototype that you don't like?

There weren't any suggestions offered by participants on how to improve any of the proposed ideas or negative feedback presented toward the proposed ideas. There appeared to be lots of positive interest in the proposed designs from the participants. The only concern they had was the potential cost of the unit.

On receiving this positive feedback, a suggestion was made for a participant to test one of the full-scale prototypes. It was explained that the prototype would be given free of charge to the participant willing to test and use it in return for their feedback. However, this offer was turned down by the participants. The reason offered for this was that it was too much of a hassle to use the trailer which was contrary to the positive feedback given just minutes before. With the participants refusing to test the prototype, it was impossible to demonstrate the benefits and design features of the proposed design idea. It was difficult to understand this response from the participants, however this decision may have been influenced by social, cultural and economic factors that had not been foreseen by the researcher or simply just a random event. This randomness is described as 'chaotic' by Gleick in his book Chaos: Making New Science. (Gleick, 1987)

Fig 260.

Fig 262. Presenting the trailer prototype to the local

Figs. 260. & 261. Scale models and visual aids were used to gather feedback

6.3.7 Reflection

Reflecting on this situation, a few factors may have caused the unwillingness of the participants to participate in the prototype testing (which was later confirmed by the local contact).

1. There seemed to be disbelief and distrust toward the idea, and a suspicion of possible hidden costs which may occur after the participant agrees to participate in the prototype testing. This would have been strongly influenced by the increase of fraud in the area.
2. Giving something "free of charge" may not be a common social practice inherited or acquired by participants.
3. A free to use prototype (with no cost) may imply special attention would need to be given to looking after the 'barrow' prototype and maintenance would become the participant's responsibility.
4. The idea of supplying feedback in the future may not appeal to participants who may perceive it as extra work on top of their busy life.

6.3.8 User Testing Two

After taking into consideration the local weather forecast, Karawang was visited again on Friday 8 January 2010 to attempt to test the prototype. With the insights gained from the first attempt, the neighbouring village in the same farming area was visited early in the morning to avoid disrupting midday Friday prayer time (up to 89% of the Indonesian population is Muslim). (Imam Reza (A.S.) Network, n.d.)

Based on information from a local contact, the house of a poultry farmer called Supriyono was visited for an informal interview regarding the use of the bicycle as a work horse. Supriyono collects grass everyday in the early morning for his farm animals from a nearby forest area and uses his bicycle as a push cart. It takes forty minutes to ride his bicycle to the forest

Fig 263. Supriyono on his way home

and two hours to walk his bicycle home with two big sacks packed with grass, each weighing around 40kg. Just before nine in the morning, the researcher arrived at the location and got to witness first hand how Supriyono uses his bike as a push cart on his way back home.

When asked about using a trailer, he said he had never thought of it. When he was told that a trailer (without mentioning it was a prototype) was about to be given away, he was very interested in taking it. Next to Supriyono's house, there is a simple shack that is used to sell secondhand bicycles and which doubles as a bicycle garage. It is owned by a 60 year old local man who took a personal interest in the prototype then proceeded to lend his tools and help with the set up.

To use the prototype trailer, firstly the steel tow brackets needed to be put onto both sides of the bicycle. After demonstrating how this was done on one side of the bicycle's rear wheel, Spriyono was given a chance to attach the other side himself. The whole process of putting on both tow brackets took only 12 minutes. It didn't take long before some locals joined in to witness the whole process. An empty bus stopped across the road from the bicycle garage

Figs 264

Figs 264 & 265. Putting the trailer attachment onto the bicycle and the driver came over to join the rest of the newly gathered audience. Supriyono was given Prototype 1 which was constructed of steel rod. This decision was based on the smaller loads he usually carried and his daily use of the bicycle as a work horse. These points of consideration were also explained to Supriyono while a demonstration on how to attach the trailer onto the tow bracket was given.

He was also told that Prototype 2 was designed to carry heavier loads such as sacks of rice by padi farmers. Supriyono pointed out that one of his friends in the audience, whose name was Andi, was a padi farmer and owned a small padi farm. To cut down the labour expense, he and his family do most of the work themselves. Their labour includes the padi cycle from planting to harvesting through to delivering the rice to the village co-op. When asked if he owned a bicycle and if Prototype 2 would be useful to him, his eyes widened and he nodded his head (yes) without a word. For a minute he stood still while staring back at the researcher, as if he was waiting to be asked a second time to make sure he was hearing correctly.
When asked where his bicycle was, he said he would go and get it as it was back at his house. He then jumped onto a motorcycle taxi and disappeared around the corner. It took him less then ten minutes to return on his bicycle, wearing a full-face motorcycle helmet! Andi's bicycle was identical to Supriyono's – they were both 1970s Phoenix models made in China.

Fig 266. Andi's Phoenix bicycle

Fig 267. Trailer on Supriyono’s bicycle

Fig 268. Trailer on Andi’s bicycle

Fig 269. Supriyono making some adjustments

Both users were given the freedom to interact with their prototypes without interference from the researcher. The researcher was simply there to observe the reaction and the participants’ response to the prototype during the testing process. This observation stance was also to see if the proposed design was simple enough to be understood by the users. All the data gathered from this testing was used to further develop the design idea.

Fig 270

Fig 271

Fig 272

Figs 270-273. User testing of one-wheel trailers

Fig 274

Figs 274 & 275. Loads were put on both trailers

Fig 276

With both prototypes attached to their respective bicycles, both Supriyono and Andi were given the chance to try the prototype without a load at first. Without any load, both riders looked quite happy with the prototype and had no major concerns with the handling of the bicycle. After a couple of rounds both riders managed to understand the limitations of the prototypes when cornering. A few locals in the audience gave positive compliments about the visual aspect of the prototypes.

Figs 276 & 277. Trailer testing with the loads on

When a load was introduced onto the prototype, it was expected that it would interfere with the handling of the bicycle and need some getting use to. The load affected the balancing of the bicycle, especially at the start when taking off. It was soon realized by Supriyono that the gravity weight balancing on a single wheel caused the prototype to sway from side to side. He then proceeded to tie the arm that connects the trailer to the tow bracket with a used inner tube tyre to reduce the amount of movement between the bicycle and the trailer. However, his action made the effort of balancing the bicycle even harder as any slight angle on the bicycle position would cause the dead weight to tip the entire bicycle to the side with no room for

Fig 278

Figs 278. & 279. Informal discussion with the locals

recovery. After failing to take off on the first try with the trailer locked onto the bicycle frame, he then untied the trailer. With a little balancing act at the start, he succeeded in riding his bicycle with a load on the trailer on the second try. It was like learning to ride a bicycle for the first time where the rider needs to find balance and get used to the extra weight. As soon as they managed to get the momentum going, their ride became easier. There were signs of pride and joy in Supriyono's and Andi's expression while they were testing their respective prototypes.

One of the locals apologetically suggested that the system would need to have two wheels. It was then explained to them that the idea was to enable them to use the prototype not only as a trailer but also as a wheel barrow that can be taken into the padi field. A one-wheel barrow can negotiate the narrow footpaths of the padi field whereas a two-wheeled barrow would not be suitable in the same environment.

Fig 280

This revelation sparked a new curiosity among the locals which encouraged them to pick up and try the prototype as a wheel barrow. One motorcycle taxi driver asked if the prototype could be used on his

Fig 281

Figs 280-282. Locals testing the trailer as a wheel barrow

motorcycle. He explained that most of his customers were framers who tried to sell their produce at the market. He thought it would be very useful for him to have extra storage. Perhaps there is an opportunity to explore this design idea for motorcycles as an intermediate means of transport in the future, even though road and transport regulations for this mode of transport will be more complex. However, this current research project is focused on land based, human powered Intermediate means of transport.

6.3.8.1 Lessons learnt include:

1. Instead of trying to sell the idea of a free prototype to a participant, the researcher merely acknowledged that the trailer was available to the participant if they thought they had a use for it. Therefore they didn't feel obligated or pressured to accept the prototype.

2. There was no mention of feedback being expected from the participants at a later time. Since the location of the participants is known, it is easy to conduct another visit at a later time to view progress if required.

3. There was no mention of inspecting the prototype at a later time. This was to give the participants the freedom to treat the prototype however they feel like and make any adjustments to suit their needs. This will eliminate the fear of being held responsible for any transformation to the prototype. This way honest data can be generated from the participant that can then be used to inform future design ideas.

4. The timing of the visit was appropriate for the participants and it is very important to have a good working knowledge of the local culture to avoid interfering in their daily prayer time or another sacred ceremonies.

6.3.9 Key Insights Gathered From User Testing

The prototype testing showed a positive response from the target users, however to see real results will take more time. The participants' immediate reaction and response towards the prototype cannot be translated as a final outcome for the proposed idea. In this case, the immediate response was a positive response for the visual aspect of the prototype.

Secondary research needs to be conducted in the form of observation or follow-up user interviews at a later time to monitor progress. Time needs to be given to users to react to the proposed design idea, to see if the user would make changes or modifications to the prototype to suit their daily needs or simply abandon the proposed idea entirely.

All this will provide the researcher with useful insights for the further development of the proposed design idea. Having direct input from user could not only enhance and improve the functionality of proposed design idea but also eliminate many assumptions and the “trial and error” process.

However, it is realized that the material used (steel tube) on both prototypes does not necessarily provide a full reflection of the initial design idea which was to use bamboo. Nevertheless, the prototype testing has proved that the basic principle of the proposed design is functional as an extended storage space on a bicycle as well as a wheel barrow and the design features were simple enough to be understood by the participants to enable them to use the prototype with ease. With the intended use of bamboo as the main material this will only make the proposed design more economical and more favourable to the target users.

Another element that was noticed from the prototype testing is the “random” or “chaotic” aspect. (Gleick, 1987) The positive responses from Supriyono and Andi may not be echoed by others in the same target demography. A case in point was the visit to Leuwiliang, where assumptions were made based on the social economic background and inherited farming lifestyle of the villagers. Therefore, the bicycle with its long history as a poor man’s first choice as an intermediate means of transport is just simply not true. Some of these aspects could have been predicted earlier by observing different geography, different cultures, different framing systems, different infrastructure or local regulations. It is imperative to know what is favourable and what is not to the target user. However, there are other human aspects that are difficult to predict, which was the case with the first visit to Karawang (where the target users were known to use bicycles as their main means of transportation) and which may have been influenced by environmental factors or random events. The same new design idea may be accepted with open arms by one target group but in the same conditions and circumstances be rejected by another.

Clearly, the proposed new idea needs to be introduced earlier in the design process to the target user. This way immediate responses and feedback can be gathered on what is more favourable to the target user and the target user who is willing to embrace new ideas will be involved from the beginning. However, this may require more resources and be costlier, and more time would be needed to collect data and monitor progress. The decision to concentrate on the Karawang area where Supriyono and Andi live appears to have been favourable for the proposed idea and progress will be monitored at a later date. Appropriate attention will be given to this area using an iterative design process and a user centred design approach to further develop the proposed idea in the hope that these ideas will be helpful and serve the needs and wants of the target user. While the proposed idea is being developed it could be spread and used as a source of inspiration for other target users who are willing to adopt it.

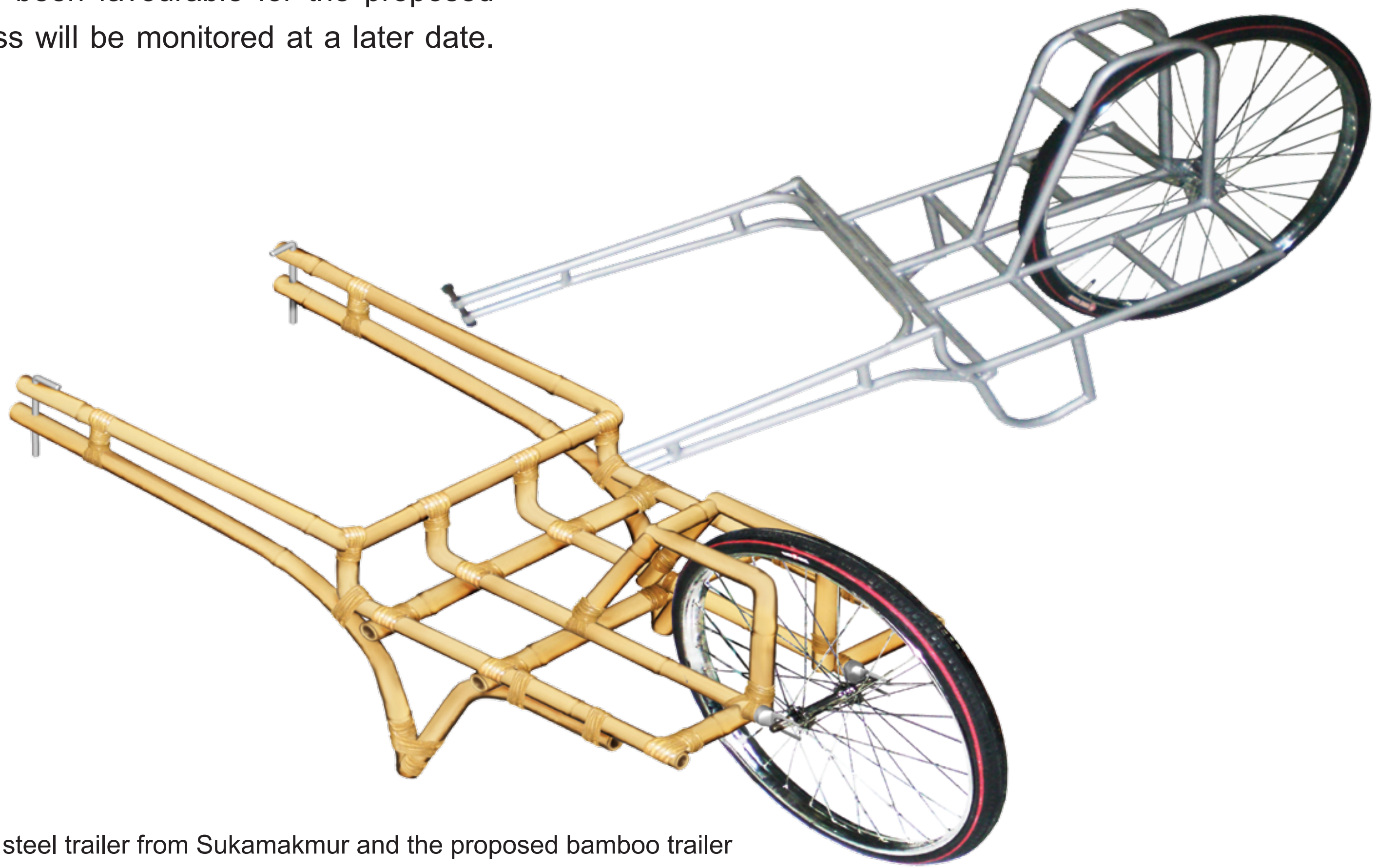


Fig 283. One-wheel steel trailer from Sukamakmur and the proposed bamboo trailer

7.1 Discussion

Subsequent to the researcher's field trip to Indonesia, the conclusion was drawn that the bicycle is still the most dominant and accessible form of transportation available for low income bracket users in most developing countries. In most parts of Indonesia, the push cart and bicycle are still the two most important and widely used intermediate means of transport, even though small to mid-sized engine motorcycles are slowly taking over some of the tasks performed by these traditional modes of transport.

Many of the land based, human powered forms of transportation in Indonesia have been converted or modified to suit the different needs of the user in different sectors. Most of these adaptations were created in back yards with a DIY approach by local craftsmen. There is no indication of any skill shortage or lack of craftsmen in rural areas such as local artisans or blacksmiths. However, in each area the skill level and knowledge of materials may vary according to the availability of raw materials and inherited culture. Therefore, it is logical to utilize existing local knowledge and skills and have locals manufacture the proposed new idea and introduce it to the market. This will not only support the local economy but create new employment opportunities for the local artisans and ensure the proposed new idea is manufactured in a way that has a familiar look to the target user. With the right approach the Greencycle project can potentially be developed into a business for target users and the local craftspeople and allied industries that support the various materials and skills needed for its production.

The environment in the Third World is not supportive of the traditional techniques used for new idea deployment. Any proposed new ideas need to follow a process of field research and use an iterative design approach to evaluate the progress

Fig 284. Greencycle evolution

of the proposed idea. A conference held at the University of California, Berkeley (USA) on Transportation in Developing Countries highlighted a complex set of issues that arise when developing the right solution due to the poor quality of available data and a lack of infrastructure. (University of California, 1998). In his paper, Professor Starkey pointed to the difficulty of gathering valuable lessons relating to the adoption of new innovations in intermediate means of transportation in Third World countries such as India and Sub-Saharan Africa. Many innovations have simply died out because the target users did not perceive the improvement as being worth the extra cost, even though early research indicated that the target user would pay for it. (Starkey, 2001)

7.2 New Design Approach

Based on the insights gathered to date from this research study, a new model of design approach needs to be considered and developed. The Greencycle will have three different design approaches, these are:

1. To provide the target user with new ideas for human powered transportation which can be manufactured economically using local skills and readily available and commonly used materials such as bamboo.
2. To provide target users with a series of ideas which act as a menu of different attachment options to their bicycle's

Fig 285. Padi field in Indonesia

which further enhance its use and meets user needs while providing a platform for further adaptations.

3. Using an iterative design approach to include the target users as part of the exploration and development process of the proposed idea.

7.2.1 Iterative Design Approach

By using an iterative design approach where the target users' feedback is used to inform the design exploration and development process, based on their needs and wants, the design process will continually evolve until the desired outcome is reached. The advantage of this iterative approach is that it eliminates any bias or preconceived ideas by the designer and will provide the designer with the most current information which then can be used to inform and develop the proposed idea. This approach can also be used as a constant reminder to identify any shift in technology or any changes in design or social trends. For the target user, this process would also create ownership of the design which would then have a greater chance of being adopted for their daily use.

The first stage of this iterative design approach has already been implemented by distributing the two prototype trailer/wheel barrows to two Indonesian village locals for their use. A follow-up visit will be made to monitor progress and gather relevant information concerning any changes or modifications made to the prototypes by the users. This information will then be used to further inform the next stage in the design process to improve the next generation prototype(s). This iterative design cycle will then be repeated when the new improved prototype is again distributed.

However, this iterative design process has its drawbacks; the process will evolve over a longer time period thus incurring additional costs to gather the required information. For this process to be viable and succeed long term, the researcher has identified the need to bring on board private or public (government) sector sponsorship to monitor progress and supply ongoing information to support the desired outcome of this project.

7.3 Conclusion

Many factors have contributed to the current fragility of our planet's environment. Key contributors like global warming, oil consumption and rubbish disposal have had a considerable impact on our environment. This has caused a global shift in people's thinking and a desire to look at new ways of dealing with existing problems. The amount of research information about global warming, climate change and carbon levels that has been done over the past sixteen years is staggering. Sustainability and the driving force to invent or discover greener energy consumption for our industry, home and work have become some of the most critical concerns worldwide.

True sustainability can't be gained by merely inventing new things. The world has become unsustainable because of too many new products or other factors which contribute to polluting the environment. To achieve true sustainability, it will require serious consideration and strategic thinking by designers and manufacturers to come up with better solutions for products that have minimal impact on the environment.

The design and development of a new product for the current market is not an easy matter. A good design is not simply a functional and usable artifact. What is now required of designers and manufacturers is to consider design as a more holistic endeavor; the design must not only satisfy the user's needs and wants but also satisfy the manufacturers need for competitive advantage as well as being good for the environment. Therefore, this research project has applied a trans-disciplinary approach involving human, artifact and environmental factors to ensure that when this approach is applied, it results in a product that is beneficial to the users, manufacturers and the environment.

Fig 286. Cherry Tree

McDonough and Braungart (2002) proposed that we can be "wasteful" if the products we produce are completely reborn as new products or go completely back into nature. Using a cherry tree as an example, they note how "wasteful" it is. Each year it dumps a great pile of fruit and leaves on the ground to rot. But all of this waste goes back into nature to be reborn as new trees, bacteria, food for birds and other parts of the natural ecosystem. According to the authors, we should try to emulate this natural system instead of trying to do more with less.

The Greencycle project has taken note of this wisdom and has gone beyond just the use of a sustainable material by also ensuring the product is sustainable in other areas, such as the socio-cultural factors, the skill level of the community and their needs and wants, and, last but not least, the competitive advantage of the product/design that could exist in the market place. The creation of the Greencycle is intended to improve people's lifestyles and the functionality and usability of a widely used form of local transportation in poorer Third World economies such as parts of China, Indonesia and Africa, etc.

Improving the humble bicycle, currently being used by over a hundred million people, with a human centred design approach, could add significant meaning, functionality, usability, sustainability and a greener operational mode of transportation for millions of people in Third World countries. This thesis has outlined the problems and opportunities and the research and design methods that will be used to design a Greencycle as a more functional form of human powered transportation.

Throughout this research project, it has also become apparent that having an understanding of the human lifestyle plays a big role in defining the impact on sustainability issues. Thus the technical aspects of this project cannot be truly successful in its outcome until this understanding, its cultural relevance and the sustainable practices of the target population are understood. While this research project has explored and produced appropriate solutions within the context of its aims and objectives, it has opened up new opportunities for further exploration and research in the area of sustainability practice relevant to culture.

At times the process has been challenging, however evaluation of the test rig, models and prototypes has received a very positive and enthusiastic response from the stakeholders, signalling a likelihood that the products will be adopted and be commercially viable when put into the market place. While this project focuses mainly on farmers and the lower income demographic group in Third World countries, the strategic thinking and model can be applied to any First World country to achieve greater sustainability. There is now a global consciousness of the need to reduce carbon footprints and promote healthier living, and the bicycle, as an intermediate means of transportation, is the perfect vehicle to achieve greater sustainability socially, economically and environmentally.

Due to this research being constrained by a 12 month time frame, readers need to be cautioned to consider the research findings and outcomes with this constraint in mind. Therefore any development of the Greencycle and accessories would need further substantiation, testing and experimentation for optimum functionality, safety and usability for the user.

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Greencycle

A Human Centred Design Approach for the Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries

VOLUME 2

Paulus Maringka

The thesis is submited to the
Auckland University of Technology
in partial fulfilment of the degreee of
Master of Philosophy

July 2010

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Volume 2 - Appendices

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AE8

Application for Ethics Approval for Research Projects

Auckland University of Technology Ethics Committee (AUTEC)

EA8

APPLICATION FOR ETHICS APPROVAL FOR LOW ETHICAL RISK RESEARCH PROJECTS

Please read the notes at the end of the form before submitting this application.

A. General Information

A.1. Project Title

If you will be using a different title in documents to that being used as your working title, please provide both, clearly indicating which title will be used for what purpose.

Greencycle - A Human-Centered Approach for the Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries.

A.2. Applicant Name and Qualifications

When the researcher is a student (including staff who are AUT students), the applicant is the principal supervisor. When the researcher is an AUT staff member undertaking research as part of employment or a staff member undertaking research as part of an external qualification, the applicant is the researcher. Staff should refer to Section 11.4 of Applying for Ethics Approval: Guidelines and Procedures *to check requirements for ethics approval where they are studying at another institution.*

Professor Leong Yap

A.3. Applicant's School/Department/Academic Group/Centre

School of Art and Design / Product Design

A.4. Applicant's Faculty

Faculty of Design & Creative Technologies

A.5. Student Details

Please complete this section only if the research is being undertaken by a student as part of an AUT qualification.

A.5.1. Student Name(s):

Paulus Maringka

A.5.2. Student ID Number(s):

0959988

A.5.3. Completed Qualification(s):

4 years Diploma in Design

A.5.4. E-mail address:

paulus_mk@hotmail.com

A.5.5. School/Department/Academic Group/Centre

School of Art and Design / Product Design

A.5.6. Faculty

Faculty of Design & Creative Technologies

A.5.7. Name of the qualification for which this research is being undertaken:

Master of Philosophy

A.5.8. Research Output

Please state whether your research will result in a thesis or dissertation or a research paper or is part of coursework requirements.

This is a practice based research project. The thesis will consist of the design and development of creative work which represents the main body of research. This is supported by a dissertation that discusses the work. The practical work constitutes 80% and the dissertation constitutes 20% of the project value.

A.6. Details of Other Researchers or Investigators

Please complete this section only if other researchers, investigators or organisations are involved in this project. Please also specify the role any other researcher(s), investigator(s) or organisation(s) will have in the research.

A.6.1. Individual Researcher(s) or Investigator(s)

Please provide the name of each researcher or investigator and the institution in which they research.

N/A

A.6.2. Research or Investigator Organisations

Please provide the name of each organisation and the city in which the organisation is located.

N/A

A.7. Are you applying concurrently to another ethics committee?

If your answer is yes, please provide full details, including the meeting date, and attach copies of the full application and approval letter if it has been approved.

No

A.8. Declaration

The information supplied is, to the best of my knowledge and belief, accurate. I have read the current Guidelines, published by the Auckland University of Technology Ethics Committee, and clearly understand my obligations and the rights of the participant, particularly with regard to informed consent.

Signature of Applicant	Date

(*In the case of student applications the signature must be that of the Supervisor)*

Signature of Student	Date

(*If the research is a student project, both the signature of the Supervisor, as the applicant, and the student are required)*

A.9. Authorising Signature

Signature of Head	Name of Faculty/Programme/School/Centre	Date

B. General Project Information

B.1. Project Duration

B.1.1. Approximate Start Date of Primary Data Collection

Mid August 2009

B.1.2. Approximate Finish Date of Complete Project

April 2010

B.2. Are funds being obtained specifically for this project?

If your answer is yes, then you must complete section C.3 of this Application Form.

No

B.3. Types of persons participating as participants

Please indicate clearly every one of the following categories that applies to those participating in your research.

B.3.1. Researcher's students

No

B.3.2. Adults (20 years and above)

Yes

B.3.3. Legal minors (16 to 20 years old)

No

B.3.4. Legal minors (under 16 years old)

No

B.3.5. Members of vulnerable groups

e.g. persons with impairments, limited understanding, etc. If your answer is yes, please provide a full description.

No

B.3.6. Hospital patients

No

B.3.7. Prisoners

No

B.4. Does this research involve use of human remains, tissue or body fluids which does not require submission to a Regional Ethics Committee?

e.g. finger pricks, urine samples, etc. (please refer to section 13 of the AUTEC Guidelines). If your answer is yes, please provide full details of all arrangements, including details of agreements for treatment, etc.

No

B.5. Does this research involve potentially hazardous substances?

e.g. radioactive materials (please refer to section 15 of the AUTEC Guidelines). If your answer is yes, please provide full details.

No

B.6. Research Instruments

B.6.1. Does the research include the use of a written or electronic questionnaire or survey?

If your answer is yes, please attach to this application form a copy of the finalised questionnaire or survey in the format that it will be presented to participants.

No

B.6.2. Does the research involve the use of focus groups or interviews?

If the answer is yes, please indicate how the data will be recorded (e.g. audiotape, videotape, note-taking). When interviews or focus groups are being recorded, you will need to make sure there is provision for explicit consent on the Consent Form and attach to this Application Form examples of indicative questions or the full interview or focus group schedule.

Yes (please see C.1.3.)

B.6.3. Does the research involve the use of observation?

If the answer is 'Yes', please attach to this application a copy of the observation protocol that will be used.

No

B.6.4. Does the research involve the use of other research instruments such as performance tests?

If the answer is yes, please attach to this application a copy of the protocols for the instruments and the instruments that will be used to record results.

No

B.6.5. Who will be transcribing or recording the data?

If someone other than the researcher will be transcribing the interview or focus group records or taking the notes, you need to provide a confidentiality agreement with this Application Form.

Myself

B.7. How does the design and practice of this research implement each of the three principles of the Treaty of Waitangi (Partnership, Participation and Protection) in the relationships between the researcher and other participants?

Please refer to Section 2.5 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures *(accessible in the Ethics Knowledge Base online via* http://www.aut.ac.nz/about/ethics*) and to the relevant Frequently Asked Questions section in the Ethics Knowledge Base.*

Although this project does not specifically target Maori, greatest care will be shown to ensure any cultural needs are addressed to the participant's satisfaction. Specialists (Product Designer, Technologist, Product Developer, and Bicycle Manufacturer) will be selected and invited to enter into a consenting partnership of sharing knowledge, experience and their perspectives with the interviewer. Their (consented) participation in this research indicates a willingness to engage and contribute to a collective good design understanding. Participants are willing volunteers, they have agreed to participate in the study with the explicit commitment by the researcher that their anonymity and confidentiality will be protected and preserved throughout the research process (from selection to publication of research findings). Partnership between researcher and participant and the opportunity to participate in the research process as well as protection of participant's contribution and identity are fundamental to this research initiative.

The research design and practice encourage a mutual respect and benefit by recognizing the key informant interviewees as an expert in their work field. Therefore, they hold unique experiences and knowledge that are able to contribute toward a greater understanding of issues around design usability, material and manufacturing processes for the design of a "Greencycle". Both parties agree to the interview from a position of understanding and respect for the sharing of ideas, thoughts and processes around the topic of usability, material and manufacturing processes in design. The discipline of design on good faith collaboration and mutual respect between parties is an implicit component of successful working relationships and interactions. The interviewer is a designer and therefore has a thorough understanding of the values and processes (and language) of design process. While the outcomes of this project are not specifically designed to benefit the participants, it is anticipated that the outputs from the study may be of interest to participants in the future.

The participants are being asked to share their understanding and perspectives regarding issues surrounding usability, materials and manufacturing processes and how they may relate to design and the environment in a third world country context. Participants will not be asked to inform or influence the nature of the research, its aims or methodology; nor do they have a formal role as stakeholders of the research. Their role is principally one of information sharing. Participants will not be asked to take a formal role in the research outputs, however outputs of the research will be made available to all participants.

Participants will be protected from deceit, harm and coercion. The study is entirely voluntary. A clear and explicit information sheet will be given to each potential participant, clearly describing the objects, methods and purpose of the study. At no time during interviews will the interviewer deviate from the purpose of the study. The location of the interviews will be agreed upon by both parties to protect their safety. The privacy of participants will be protected by referring to participants as "interviewee1…etc"

Extreme care will be taken not to present material that may be linked back to individuals or the organizations they work for. No descriptors of the participants or their organization will be used. Participant's anonymity will be protected throughout the study from initial selection through to the presentation of findings. It is not anticipated that there are any power imbalances. The interviewee's are professionals and the interviewer is a design lecturer and design practitioner. There is nothing to compromise the safety of either parties, nor the integrity of the study. However, if either party feels there is a power imbalance they are able to withdraw from the study. This is clearly referred to in the participant information sheet.

The integrity of any research process can be measured by the respect and acknowledgement afforded to participants cultural (including ethnic and gender) diversity. The interviewer is a New Zealand Permanent Resident /Asian male and therefore interviews will be conducted with respectful awareness and acknowledgement of diversity of experience, values and belief structures between interviewer and participants.

B.8. Does this research target Maori participants?

No

B.8.1. If 'Yes", what consultation has been undertaken when designing the research?

Please identify the group(s) with whom consultation has occurred and provide evidence of their support and any impact this consultation had on the design of the research. Researchers are advised to read the Health Research Council's Guidelines for researchers on health research involving Maori*, available via the Ethics Knowledge Base.*

N/A

B.9. Does this research target participants of particular cultures or social groups?

Please refer to Section 2.5 of AUTEC's Applying for Ethics Approval: Guidelines and Procedures *(accessible in the Ethics Knowledge Base online via http://www.aut.ac.nz/about/ethics) and to the relevant Frequently Asked Questions section in the Ethics Knowledge Base.*

Yes

B.9.1. If 'Yes" please identify which cultures or social groups are being targeted and how their cultures or social groups are being considered in the research design.

Lower income bracket populations in third world countries

B.9.2. If your answer to B.9 was 'Yes", what consultation has occurred with these cultures or social groups in the design of the research?

Please identify the group(s) with whom consultation has occurred and provide evidence of their support and any impact this consultation had on the design of the research.

Final Evaluation methods: Six participants will be selected and invited to enter into a consenting partnership to share their point of view on product prototypes based on their knowledge and experience with the interviewer. Potential participants will be recruited from a targeted demographic whose livelihood and income is derived from bicycle use. Potential participants will be chosen buy a local leader who knows the background of the participants.

Participants background information:
Participants will be selected from the residents of Village Sukamakmur. Village Sukamakmur is located in the Kabupaten region of Karawang, about 70km outside Jakarta (the capital city of Indonesia) in West Java Island, Indonesia. The landmass of Kabupaten Karawang is 1.753,27 km2s or 175.327 ha, with the composition of land use being mostly farmland.

Reason for choosing these particular participants:
The researcher was born and raised in Indonesia and has an intimate (tacit knowledge) understanding of the culture and is fluent in the native language. This and the fact that they are farmers and heavy bicycle users are the main reasons for choosing this demographic group for the research project. The fact that the researcher and participants are all of the same nationality and speak the same native language, will contribute to the success of the research. Besides the reasonable easy access to the area, the population of Village Sukamakmur heavily relies on farming as their main income source. Their first-hand experience and knowledge is ideal to be able to contribute toward the evaluation around design and usability of the proposed product. This targeted group belongs to a relatively low income demographic group and low educational background which makes them suitable participants in this research project.

Based on information drawn from reviewing literature and journals (West j, 1990), three important steps will be initiated prior to the interviews taking place. These steps are imperative to show respect to their community and culture and also to provide stability throughout the research project.

1. One month prior to the interview, a local leader (government employee) will be contacted through a local contact who has been fully briefed on the research subject, inviting their participation. It needs to be noted that the local contact is a close friend of the researcher and also shares the same interest in bicycles but is not a researcher, nor will he conduct any interviews. The local contact's participation is simply to act as a messenger in this research. The local leader is an official government employee who is in charge and represents the people in the village. The support and personal Involvement of the locally acknowledged leader will greatly assist in gaining access to the group of participants who have consented to be interviewed. It is anticipated the same local leader will continue to lend support to the researcher as they implement their findings in the future.

2. The purpose and procedure of the interview will be clearly outlined to the local leader when the first contact is made. The research aims and purpose will be clearly laid out in the form of printed material in the native language of Indonesia. This will provide a clear outline of the research project should questions arise. This

material will also highlight the potential benefit of the proposed research project outcomes. This will allow the local leader to advise the residents as to the purpose of the interview prior to the interview taking place. However, researchers need to be aware that in conducting projects of this type, that they should not raise false hopes of change among the participants.

3. With the agreement of the local leader, a convenient interview time, place and date will be established. This is an effort to avoid interfering in the daily prayer time and any other religious ceremonies which are considered sacred to the community.

The same local leader's participation will be anticipated when the interview takes place in gaining entrance into a research site, addressing cultural differences, identifying research participants who are literate and they may also arrange transportation to isolated sites for the interview component of the process. Also, allowing sufficient time to conduct the project is one of the many challenges most researchers may encounter in the field study.

Scale 3D prototypes of concept bicycles and accessories with visual aids to describe the functionality and usability of the proposed design will be presented to participants throughout the interview process. This method of approach is simply to avoid alienation of any participant as literacy is the biggest challenge in the targeted group. The participants will be asked to share their point of view and perspectives regarding issues surrounding usability and functionality and how they may relate to the design and the environment in a third world country context. Participants will be invited to share their opinion to inform or highlight any issue with the proposed design to establish any changes or modifications that they fell needs to be implemented to improve the final idea.

All participant responses to questions and any subsequent discussion from this will be held strictly confidential. The interview material can only be accessed by Paulus Maringka and Professor Leong Yap. The interview material (audio and transcripts) will be stored in a secure locker in Professor Yap's office for six years then destroyed. Where information provided by the participant is published, the interviewee will be referred to as "Interviewee 1...etc" or similar to protect anonymity. All participants will have the right to withdraw from the project at any time at the interview.

B.10. Is there a need for translation or interpreting?

If your answer is 'Yes', please provide copies of any translations with this application and any Confidentiality Agreement required for translators or interpreters.

Yes, the Consent Form, Participants Information Sheet and the Sample Questions will be translated into Malay (Indonesian native language)

Methodological and Ethical Information

When completing this section, the applicant is advised to consult AUTEC's Applying for Ethics Approval: Guidelines and Procedures*, which is accessible online through* http://www.aut.ac.nz/research/ethics *.*

B.11. Please provide full descriptions of the following aspects of the proposed research:

B.11.1. The aim and background

Project Back Ground

The main aim of this Master of Philosophy research project is to research, propose and construct new types of human powered transportation concepts for developing and third world countries. This research is an attempt to use design thinking and innovation to improve on the bicycle and push cart forms taking into account functionality, the needs and wants of the users, appropriate technologies and environment sustainability. Another aspect of this research is to look at more economical and cleaner manufacturing processes and also the after life-cycle of the product by exploring a cradle to cradle model to eliminate or make wasteful or hazardous processes more sustainable. (McDonough W. & Braungart M, 2003).

Problems and Opportunities

Two of the most basic forms of transportation in developing and third world countries are the push-cart and the bicycle. Currently, bicycles and push-carts are still widely used in less developed countries as a major part of their daily life. They are used to carry farm produce to market, take children to school and occasionally act as a carriage to take a loved one for a romantic ride under the moonlight. They act not only to transport goods, but for many users they have become an integral part of their livelihood and earning a living.

Fig.01

Fig.02

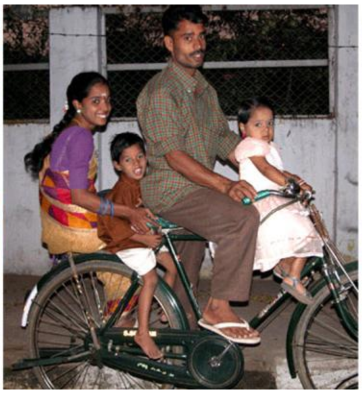


Fig.03

Fig.04

Fig 01. A bicycle which has been modified to suit the user's need such as taking kids to school in China.

Fig 02. In third world countries, it is very common that farmers convert their bicycles to take their produce to market.

Fig 03. In India, the bicycle has a myriad of uses and is still the most economical and ecological form of transportation available to many.

Fig 04. In parts of Africa, the bicycle is commonly used as a work-horse instead of just a form of transportation.

The motorcycle, with all its best intentions, is not always suited for rural environments, for example a padi (rice) field. The main issues related to motorcycle ownership is the lack of fuel available in remote places and the costs of licensing, government regulation and ongoing maintenance. All of which make the motorcycle a less desirable form of transportation in poorer communities.

Since the 1950's, in parts of third world countries like China, the bicycle has become the dominant form of transportation where it is seen as a status symbol and something to aspire towards having. Today, bicycles are still the most ideal form of transportation, providing a convenient, economical and ecologically friendly way to get around.

Fig 05. A cyclist with his child trying to cross the road at a busy intersection in Beijing

Recently, on-road bicycle numbers have been eclipsed by the car. China with a population of 1.3 billion is predicted to have 140 million cars plying its roads by the year 2020. The Deputy Director of the Communication Ministry's Comprehensive Planning Department, Li Xinghua, predicted that the number of cars in China will eventually reach 250 million or about 150 cars for every 1000 people. (Business Report, section id: 565 & article id: 2211763. September 3,2004)

It is also predicted that by 2050, India with a population of 1.1 billion, will have 382 cars per thousand people compared with China's 363 in that same year. (Business report: India to top in car volumes by 2050 by S Kalyana Ramanathan in New Delhi I October 23, 2004)

With the depletion of raw materials and oil in some parts of the world, these car numbers are staggering and unsustainable. The American Petroleum Institute in 1999 predicted that the world's oil supply would be depleted between 2062 and 2094 with the increased rate of current oil consumption. (Oil Depletion, Wikipedia.December 22, 2008).

These predictive statistics really outline the urgent need for more sustainable forms of transportation not only to reduce carbon emissions but also to produce more practical and affordable solutions with consideration to the environment and material resources.

In addition to of all this, the existing design of human-powered forms of transport is no longer efficient to fulfill the needs of its users whose livelihoods depend heavily upon it. This opens up a new opportunity to explore, design and develop a hybrid human powered transportation that meets the current and future requirements of functionality, usability, affordability, sustainability and desirability.

With the combined population of China and India alone being **2.4 billion**, the research for this project could provide the frame work and opportunity to bring about real economic, functional and sustainable solutions for low income users.

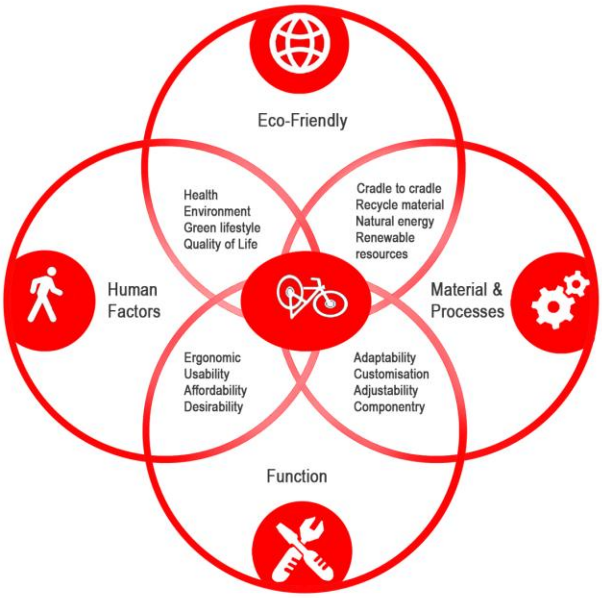
Aim and Research Study

By researching, analyzing and integrating all the positive aspects of the bicycle, push-cart and motorcycle and the advantages each provides, a new form of human-powered transportation will be designed and developed that incorporates all the elements suitable for modern use.

This project will also explore user and environmental needs to inform a manufacturing process that eliminate or minimize the use of any hazardous chemicals or materials by utilizing readily available natural resources. These natural resources will become the main material component used in this proposed project.

At the conclusion of this research study, it is intended that this practical-based project will be able to come up with a highly functional form of hybrid human powered transportation which will meet the user needs in functionality, economic and manufacturing (material and processes) sustainability.

Diagram showing an integrated approach to the different details of design criteria of the proposed Greencycle.



B.11.2. The procedure, including the methodology and the methods of data collection and analysis

METHODOLOGY

The Research Methodology will consist of "Mixed Methods" of both positivist and interpretive research to capture data and understanding to inform the design. Design Methods consisting of heuristic method will be used for the ideation, concept development and prototyping.

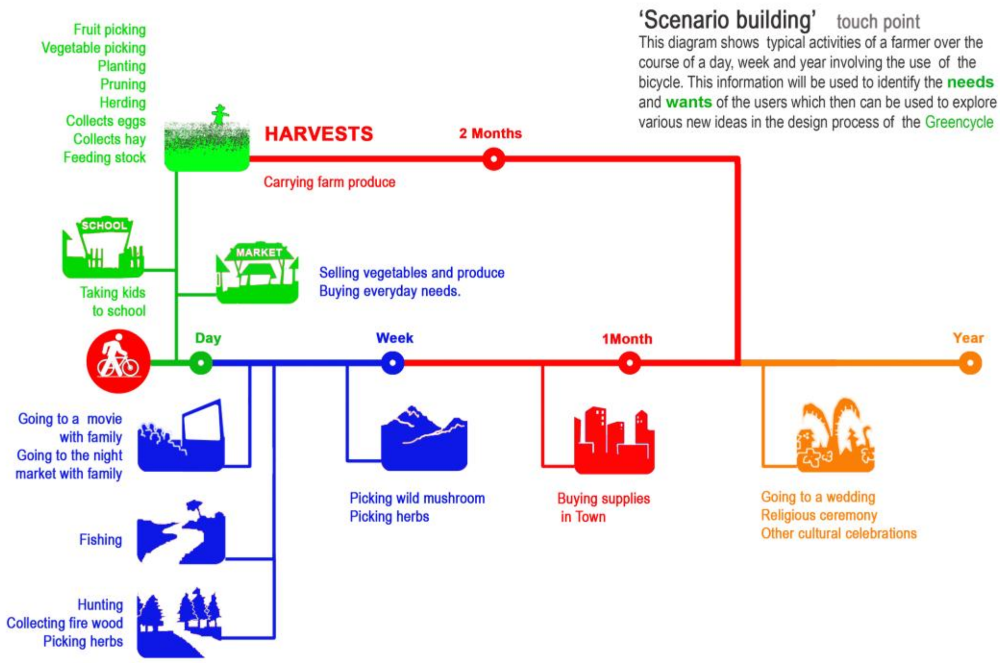
RESEARCH METHODS (Rational Methods)
In the first stage, both quantitative and qualitative research methods will be used to gather information and data to generate understanding and knowledge which then will be analysed and used as part of the design exploration process. In order

to achieve this goal, it is necessary to gain a deeper understanding of the relationship between the users, materials, processes, needs and function of human powered transportation by:

1. **Literature Review** will focus on the relationship between people and human powered transportation. Human–centered design will be one of the main aspects of my research to explore and evaluate the user's needs, design ergonomics, aesthetic value, functionality and desirability of the product to achieve the optimal outcome. Research will include reviewing literature on different forms of human powered transportation to compare and evaluate what's currently available. This will ensure valuable insight into the needs, wants and desire for a more functional and sustainable type of human powered transportation.

2. **Internet Research** methods will be used to explore and gather historical visual and textual information on this topic to provide a good understanding on the relationship between people and transportation from real cases in the real world.

3. **Scenario, Personas and Touch points**. Having a genuine interest in the subject, the researcher was born and grew up in Indonesia and this has enabled him to create Scenario from tacit knowledge and gather information regarding the relationship between man and human powered transportation focusing on their functionality and usability. This method works better to obtain the information needed for this project as opposed to interview or questionnaire methods because of the nature of the target group where illiteracy is one of the biggest problems. This information will be used to identify the needs and wants of the users which then can be used to explore various new ideas in the design process of this proposed project.



3.1 **Personas** are representational characters envisioned by the researcher of the user profile, created using the tacit knowledge to represent the different bicycle user types within a targeted demographic. Personas are useful in considering the needs, desires and affordability of the users in order to gain knowledge and understanding which can help to make design decisions. Personas will only work with scenario design and walkthroughs, only then personas can bridge the gap between context of use and implementation. Scenario, Personas and touch points are important mind maps to guide the designer to design and develop product and service that makes the needs and wants of the target users.

3.2

Diagram explaining the different needs of each persona

4. **Interviews** A group of 6 experts will be interviewed. This group will consist of Users and Experts from related disciplines such as Industrial Designers, Product Developers and Manufacturers. They will be interviewed to help assess the material used and manufacturing and processes, to reinforce and validate the gathered information and knowledge from the previous methods which then can be analysed and used to inform and synthesise the design process.

5. **Design Evaluation:** The design evaluation is intended to examine whether the criteria has been met from previous research findings and to establish any changes or modifications that need to be implemented to improve the final idea.

DESIGN METHODS (Heuristic-Generative methods)
Using heuristic, generative and intuitive methods, design ideas will be explored using the knowledge gained from Persona and Scenario building and user-needs analysis. A list of function specifications, based on the information findings from the previous methods, will act as guide to the design process and exploration. A series of new ideas on human powered transportation focusing on the functionality, usability, desirability, affordability and sustainability will be developed.

Using the results of the mixed research methods, this will be used as design criteria to explore and develop the design ideas for a new hybrid form of human powered transportation. This will encompass the following heuristic and reflective design approaches:

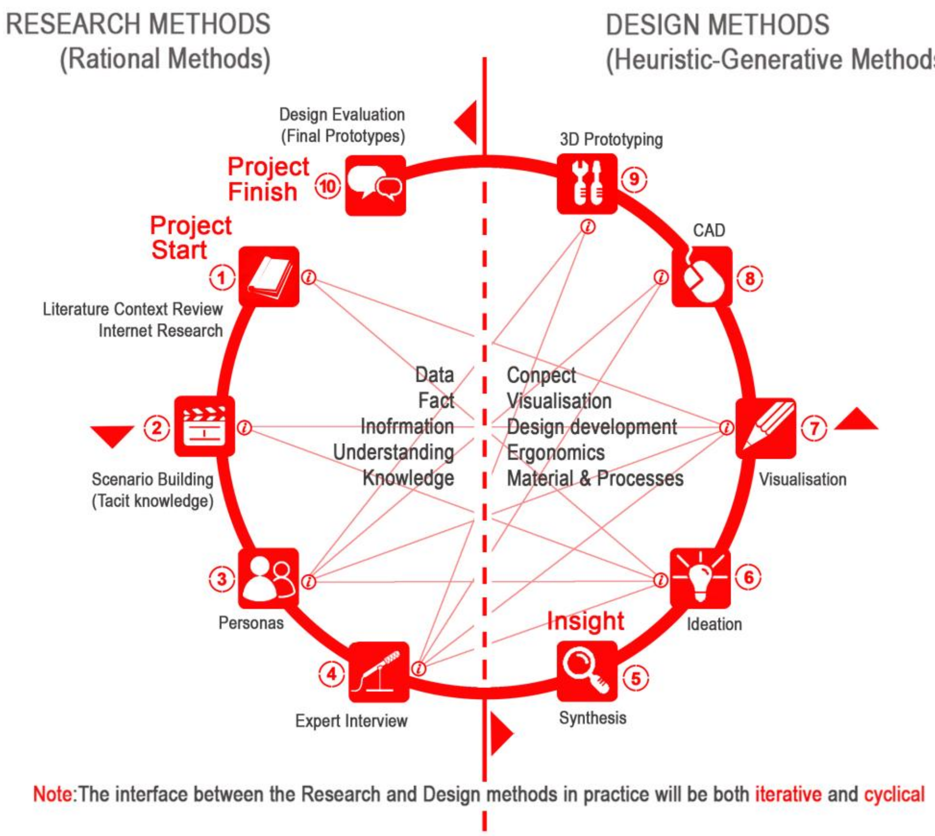
1. **Ideation:** To explore various new ideas that is informed by the data.

2. **Visualisation:** A series of design ideas will be analysed, explored, improved and developed after the user needs have been established. These visual ideas will provide a better understanding of the aesthetic value and desirability.

3. **CAD:** Software will be used to give a more realistic representation to the design ideas. Using data and information gathered from interviewing experts and

manufacturers, the design ideas will be developed and improved with a focus on dimensioning, ergonomics, materials and processes.

4. **3D Scale Prototyping:** Due to the wide scope of this project, there will be several scale models which will be built using SLR or rapid prototyping. This process is necessary to provide a realistic 3D representation of a semi working prototype.



Simplified Diagram showing design research and design methods.

However design is an iterative process, the number (sequence) does not necessary represent the design process in action.

B.11.3. The number of participants that will be involved, how they will be recruited, how they will be selected from those recruited, any exclusion criteria that will be applied in their recruitment or selection, and how their privacy will be protected.

Six participants will be recruited from 3 different discipline areas, which are; Product Design, Product Developer and Manufacturer. Potential participants will be individuals who are active in the industry of their profession. Potential participants will be chosen using a non probability purposive sampling technique.

Potential participants will be contacted by a single email containing a letter and information sheet inviting their participation. Contact details will be obtained from DINZ data base and information in the public domain. If the email is not responded to, then this will be determined as the individual declining to take part in the study and no further contact will be made. The purpose and procedure for the interview will be clearly outlined in the information sheet. Should questions arise, these can be addressed via email or telephone. With both parties agreement, a convenient interview date will be established and the interview will take place at their work or other suitable location.

All participant responses to questions and any subsequent discussion from this will be held strictly confidential. The interview material can only be accessed by Paulus Maringka and Professor Leong Yap. The interview material (audio and transcripts) will be stored in a secure locker in Professor Yap's office for six years then destroyed. Where information provided by the participant is published, the interviewee will be referred to as "Interviewee 1...etc" or similar to protect anonymity. The organization will not be named. All participants will have the right to withdraw from the project at any time up to two weeks following the interview.

B.12. Please describe how, the exact location, and for how long the data and/or Consent Forms will be stored, as well as who will have access to them and how they will be destroyed.

If data and/or Consent Forms will be stored somewhere other than AUT, or will be stored for a period other than six years, please provide a justification for this. Please note that data and Consent Forms need to be stored separately.

Information and Data will be kept/stored in the office of the Supervisor in a lock cabinet at Auckland University of Technology for a period of 6 years after which they will be shredded.

B.13. Funding Details:

B.13.1. Has an application for financial support for this project been (or will be) made to a source external to AUT or is a source external to AUT providing (or will provide) financial support for this project?

There are no special resources needed for this project from AUT - except for the use of the 3D workshop and the rapid prototyping facilities in the CIRI to construct several 3D models of the human powered transportation.

It is estimated that travel/airfares for the research, materials for the 3D models and thesis preparation and binding would cost around $5000. This cost will be borne by the student.

B.13.2. Has the application been (or will it be) submitted to an AUT Faculty Research Grants Committee or other AUT funding entity?

No

B.13.3. If the answer to C.3.1 or C.3.2 was 'yes', please provide the name of the source, the amount of financial support involved, and clearly explain how the funder/s are involved in the design and management of the research.

N/A

B.13.4. Please provide full details about the financial interest, if any, in the outcome of the project of the researchers, investigators or research

organisations mentioned in Part A of this application.

There is no financial interest in the outcome of the research

Checklist

Please ensure all applicable sections of this form have been completed and all appropriate documentation is attached as incomplete applications will not be considered by AUTEC.

Section A	General Information Completed	☐
	Signatures/Declaration Completed	☐
Section B	General Project Information Completed	☐
Section C	Methodological and Ethical Information Completed	☐

Spelling and Grammar Check (please note that a high standard of spelling and grammar is required in documents that are issued with AUTEC approval) ☐

Attached Documents (where applicable)

Participant Information Sheet(s)	☐
Consent Form(s)	☐
Questionnaire(s)	☐
Indicative Questions for Interviews or Focus Groups	☐
Observation Protocols	☐
Recording Protocols for Tests	☐
Advertisement(s)	☐
Hazardous Substance Management Plan	☐
Any Confidentiality Agreement(s)	☐
Other Documentation	☐

Before submitting this application, please note the following:

- *Incomplete or incorrectly formatted applications will not be considered by AUTEC;*
- *Please check online for the most recent version of this form before submitting your application;*
- *Please do not alter the formatting of this form or delete any sections. If a particular question is not applicable to your research, please state that as your response to that question;*

This form needs to be submitted, along with a completed EA8RA self assessment form and all associated documents as follows:

- *In electronic form;*
- *By 4 pm on the submission date to:*

  The AUTEC Faculty Representative for your Faculty (contact details for the AUTEC Faculty Representatives is available online in the Ethics Knowledge Base, accessible via http://www.aut.ac.nz/about/ethics).

Before the sub-committee meeting date, a signed and printed copy of this application form only needs to have been given to the AUTEC Faculty Representative.

Appendix B

Consent to Participation in research

Appendix B.1

Indonesian translation of Consent to Participation in Research

Consent to Participation in Research

This form is to be completed in conjunction with, and after reference to, the AUTEC Guidelines.

Title of Project: **Greencycle** - A Human-Centred Design Approach for the Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries

Project Supervisor: Professor Leong Yap

Researcher: Paulus Maringka

1. I have read and understood the information provided about this research project.
2. I have had an opportunity to ask questions and to have them answered.
3. I understand that the interview will be audio-taped and transcribed.
4. I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.
5. If I withdraw, I understand that all relevant tapes and transcripts, or parts thereof, will be destroyed.
6. I agree to take part in this research.

Participant signature: ....

Participant name: ……………………………………………………………….

Participant Contact Details (if appropriate):

………………………………………………………………………………………..

………………………………………………………………………………………..

Date:

Approved by the Auckland University of Technology Ethics Committee on <click here and type the date ethics approval was granted> **AUTEC Reference number** <click here and type the AUTEC reference number>

Note: The Participant should retain a copy of this form.

Persetujuan untuk Riset Partisipasi

Formulir ini harus di isi sejalan dengan, dan sesudah berhubungan dengan peraturan AUTEC.

Judul Proyek: **Greencycle** - Disain Riset yang Berporos Pada Manusia untuk Menganalisa , Mendesain dan mengevaluasi Kendaraan Bertenaga Manusia konsep sistem untuk Negara yang sedang Membangun dan Negara yang terbelakang

Pengawas Proyek: Professor Leong Yap

Periset: Paulus maringka

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1. Saya sudah membaca dan mengerti keterangan tentang riset proyek ini.
2. Saya mempunyai kesempatan untuk bertanya jawab.
3. Saya mengerti wawancara ini akan direkam dan disalin .
4. Saya mengerti , saya boleh mengundurkan diri atau menarik kembali informasi yang saya berikan kapan waktu sebelum pengumpulan informasi ini selesai , tanpa ada kerugian apa pun.
5. Saya mengerti , kalau saya mengundurkan diri semua informasi tertulis atau rekaman yang berhubungan akan dimusnahkan.
6. Saya setuju untuk berpartisipasi dalam riset ini.

Tanda tangan Partisipan : ....

Nama Partisipan : ……………………………………………………………

Keterangan alamat lengkap Partisipan (kalau layak):

………………………………………………………………………………………..

………………………………………………………………………………………..

Tanggal:

Disetujui oleh Auckland University of Technology Ethics Committee pada tanggal *type the date final ethics approval wasgranted*, **nomor referensi AUTEC** *type the reference number*.

Nota: Partisipan harus menyimpan tindasan lembaran formulir ini.

Appendix C

Participant Information Sheet for experts

Participant Information Sheet

For Experts

Date Information Sheet Produced:

5/08/2009

Project Title

Greencycle - A Human-Centred Approach for Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries.

An Invitation

Dear participant,

My name is Paulus Maringka. I am writing to invite you to take part in an interview on the above mentioned topic. I am currently studying for a Master of Philosophy degree in Art and Design at Auckland University of Technology. My research is on analysing, designing and evaluating Human Powered Transportation System Concepts for Developing and Third World Countries.

This is a very important part of my research study. Your opinions and feedback will contribute to the success of this research. This interview is strictly voluntarily.

What is the purpose of this research?
This interview is conducted to test and validate whether the intended design has been accurately conveyed to the needs and wants of the users, appropriate technologies and environment considerations.

How was I chosen for this invitation?
You will be selected base on your expertise. Your name was selected from the DINZ (Designer Institute of New Zealand) database

What will happen in this research?
I will explain the detail of my research aims to you and ask you five questions relating to this project. These questions will be centred on the functionality, the needs and wants of the users, appropriate technologies and environment considerations.

What are the discomforts and risks?
This interview does not involve the use of instruments such as a performance test so it is not anticipated that there will be any discomfort or risk. I am a design lecturer and design practitioner. There is nothing to compromise the safety of either parties, nor the integrity of the study.

How will these discomforts and risks be alleviated?
A clear and explicit information sheet will be given to you, clearly describing the objects, methods and purpose of the study. At no time during interviews I will deviate from the

purpose of the study. The location of the interviews will be agreed upon by both parties to protect our safety. Your privacy will be protected by referring to you as “interviewee1…etc”

What are the benefits?
There are no direct benefits, but your opinion will assist this research. It is my intention to take the final concept design and prototypes back to the users in Indonesia, who hopefully will receive the benefit from this research project.

How will my privacy be protected?
Confidentiality will be observed. All data and consent forms will be stored securely in the office of supervisor. All data will be shredded after six years.

What are the costs of participating in this research?
There are no costs associated except that you will need to spend about 30 minutes in the interviews.

What opportunity do I have to consider this invitation?
Your participation is voluntary. You will have the right to withdraw from the project at any time at the interview.

How do I agree to participate in this research?
You will be required to sign a consent form to participate in this research.

Will I receive feedback on the results of this research?
Feedback will be made available to you at the competition of this research project.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor Professor Leong Yap.
Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Whom do I contact for further information about this research?
Professor Leong Yap, leong.yap@aut.ac.nz ph 921 9999, ext 8604.
Paulus Maringka, paulus_mk@hotmail.com ph 0274 739051

Professor Leong Yap, leong.yap@aut.ac.nz ph 921 9999, ext 8604.

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number*.

Appendix C.1

Participant Information Sheet for locals

Participant Information Sheet

For locals

Date Information Sheet Produced:

5/08/2009
Project Title

Greencycle - A Human-Centred Approach for Analysis, Design and Evaluation of Human Powered Transportation System Concepts for Developing and Third World Countries.

An Invitation

Dear participant,

My name is Paulus Maringka. I am writing to invite you to take part in an interview session. I am currently studying for a Master of Philosophy degree in Art and Design at Auckland University of Technology. My research is on analysing, designing and evaluating Human Powered Transportation System Concepts for Developing and Third World Countries.

This is a very important part of my research study. Your opinions and feedback will contribute to the success of this research. This interview is strictly voluntarily.

What is the purpose of this research?
This interview is conducted to find out whether my design concepts meet your needs and wants. I also want your opinion on the function and use of the new design.

How was I chosen for this invitation?
You will be selected base on your expertise. Your name was selected by the Local Leader.

What will happen in this research?
I will explain the detail of my research aims to you and ask you five questions relating to this project. These questions will be centred on the functionality and your needs and wants, appropriate materials and environment considerations.

What are the discomforts and risks?
This interview does not involve the use of instruments such as a performance test so it is not anticipated that there will be any discomfort or risk. I am a design lecturer and design practitioner. There is nothing to compromise the safety of either parties, nor the integrity of the study.

How will these discomforts and risks be alleviated?
A clear and explicit information sheet will be given to you, clearly describing the objects, methods and purpose of the study. At no time during interviews I will deviate from the purpose of the study. The location of the interviews will be agreed upon by both parties to protect our safety. Your privacy will be protected by referring to you as “interviewee1…etc”

What are the benefits?
There are no immediate benefits, however your opinion could help me to design a new transportation system that is functional and useful for the benefit of users such as your self in the future.

.

How will my privacy be protected?
Confidentiality will be observed. All data and consent forms will be stored securely in the office of supervisor. All data will be shredded after six years.

What are the costs of participating in this research?
There are no costs associated except that you will need to spend about 30 minutes in the interviews.

What opportunity do I have to consider this invitation?
Your participation is voluntary. You will have the right to withdraw from the project at any time at the interview.

How do I agree to participate in this research?
You will be required to sign a consent form to participate in this research.

Will I receive feedback on the results of this research?
Feedback will be made available to you at the competition of this research project.

What do I do if I have concerns about this research?
Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor Professor Leong Yap.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* , 921 9999 ext 8044.

Whom do I contact for further information about this research?
Professor Leong Yap, leong.yap@aut.ac.nz ph 921 9999, ext 8604.

Researcher Contact Details:
Paulus Maringka, paulus_mk@hotmail.com ph 0274 739051
Project Supervisor Contact Details:
Professor Leong Yap, leong.yap@aut.ac.nz ph 921 9999, ext 8604.

Approved by the Auckland University of Technology Ethics Committee on *type the date final ethics approval was granted*, AUTEC Reference number *type the reference number*.

Appendix C.2

Indonesian translation of Participant Information Sheet for locals

Partisipan Lembar Informasi

Untuk Orang lokal

Tanggal lembar informasi diproduksi :

20/04/2009
(Wawancara)

Judul Proyek

Greencycle – Disain Riset yang Berporos Pada Manusia untuk Menganalisa , Mendesain dan mengevaluasi Kendaraan Bertenaga Manusia konsep sistem untuk Negara yang sedang Membangun dan Negara yang terbelakang

Undangan

Kepada Partisipan,

Nama saya adalah Paulus Maringka. Saya disini mengundang anda semua untuk ikut serta dalam survey pengumpulan data saya. Saat ini saya sedang melakukan studi untuk jurusan Master of Philosophy's di Auckland University of Technology. Riset saya ini akan menganalisa, mendesain dan mengevaluasi Kendaraan Bertenaga Manusia konsep sistem untuk Negara yang sedang membangun dan Negara yang terbelakang.

Ini bagian yang terpenting dalam proyek riset saya. Segala pengalaman dan pendapat anda akan membantu kesusksesan riset ini. Wanwancara ini berdasarkan sukarela .

Apa tujuan dari riset ini?
Tujuan dari wawancara ini untuk menguji dan mengesahkan apa disain yang dikehendaki sudah menyampaikan dengan tepat, kebutuhan dan keinginan pemakai.

Bagaimana partispan diminta untuk dipilih untuk berpartisipasi di riset ini?
Anda akan dipilih berdasarkan keahlian anda .Nama anda dipilih dari kepala desa.

Apa yang akan terjadi di riset ini?
Saya akan menjelaskan secara detail tujuan riset kepada anda , kemudian memberikan anda lima pertanyaan yang berhubungan dengan proyek ini. Pertanyaan ini akan berpusat di fungsi, kebutuhan dan keinginan pemakai, bahan yang sesuai dan pertimbangan untuk lingkungan.

Apakah ada ketidak senangan dan bahaya?
Wawancara ini tidak melibatkan peralatan untuk percobaan , jadi tidak diharapkan akan ada ketidak senangan dan bahaya. Saya adalah pengajar desain dan praktek desain. Tidak ada kompromi untuk keselamatan di dua pihak, atau kesempurnaan studi ini.

Bagaimana caranya meredakan ketidak senangan dan bahaya ini ?
Lembaran Informasi yang jelas akan diberikan kepada anda, menjelaskan tentang benda , metode dan tujuan studi ini. Dalam waktu wawancara saya tidak akan menyimpang dari

tujuan studi ini. Lokasi wawancara akan disetujui oleh dua pihak untuk menjaga keamanan mereka. Rahasia anda akan di lindungi dengan memperkenalkan kamu sebagai " yang diwawancara 1….dan seterusnya"

Apa saja manfaatnya?
Tidak ada keuntungan secara langsung , tetapi pendapat anda akan membantu saya untuk desin kendaraan yang berguna dan bermanfaat untuk pemakai seperti anda di hari depan.

Bagaimana kerahasiaan saya akan terlindungi?
Kerahasiaan akan diamati. Semua data dan formulir ijin akan disimpan dengan aman dikantor pengawas. Semua data akan di musnahkan sesudah enam tahun.

Adakah biaya yang harus dikeluarkan dalam berpartisipasi di riset ini? (termasuk waktu)
Tidak akan ada biaya yang berhubungan, kecuali anda diharapkan untuk bersedia meluangkan waktu sekitar 30 menit dalam wawancara ini.

Kesempatan untuk mempertimbangkan undangan ini?
Keikutseratan ini sepenuhnya sukarela, Partisipan mempunyai hak untuk mengundurkan diri dari proyek ini setiap waktu namun keikutsertaan anda akan dihargai.

Bagaimana cara saya untuk setuju dalam berpartisipasi didalam riset ini?
Anda akan diminta untuk menandatangani formulir ijin untuk berpartisipasi dalam riset ini.

Aapakah saya akan menerima hasil dari riset ini?
Hasil riset ini akan diberika untuk anda sesudah riset proyek ini selesai.

Apa yang harus saya lakukan apabila saya punya kekhawatiran mengenai riset ini?
Segala pertanyaan dan keraguan yang berhubungan dengan proyek ini harus diberitahukan terlebih dahulu kepada Supervisor Proyek, Prof. Leong Yap, leong.yap@aut.ac.nz, ph: 9219999 ext 8604.

Keraguan mengenai segala peraturan dalam hal-hal yang berhubungan dengan riset ini harus diberitahukan kepada Sekretariat Eksekutif, AUTEC, Madeline Banda, *madeline.banda@aut.ac.nz* ,921 9999 ext 8044.

Siapa yang harus saya hubungi untuk informasi selanjutnya tentang proyek ini?
Prof. Leong Yap, leong.yap@aut.ac.nz, ph: 9219999 ext 8604

***Detail Keterangan Peneliti**:*
Paulus Maringka, paulus_mk@hotmail.com ph 0274 739051
Detail Keterangan Pengawas Proyek:
Prof. Leong Yap, leong.yap@aut.ac.nz, ph: 9219999 ext 8604

Disetujui oleh Auckland University of Technology Ethics Committee pada tanggal *type the date final ethics approval wasgranted*, nomor referensi AUTEC *type the reference number*.

Appendix D

Sample Questions for Expert and Participant Interviews

Appendix D.1

Indonesian translation of Sample Questions for Participant Interview

Sample Questions for Expert Interviews

1. How can existing forms of human-powered transportation be further developed to better meet the needs of low income users in the third world countries?

2. What natural material and processes are the most ideal for a new type of human powered transportation?

3. Is bamboo safe and strong enough or appropriate for the new human powered transportation?

4. Do you think that customisation or modularisation will suits the needs for the new design of human powered transportation?

5. What other areas for improvements can you suggest?

Sample Questions for Participant Interviews of the Prototype

1. Does the scale model (prototype) give you the functionality and usability need as a farmer?

2. What do you think of bamboo as a material for a bicycle?

3. Do you think that customisation or modularisation will improve your needs?

4. Does the look of Greencyle appeal to you and what do you like the most about this prototype?

5. What other areas that you can see from the prototype need for improvements?

Contoh Pertanyaan untuk Partisipan Wawancara tentang Prototipe

1. Apakah skala model ini dapat memberikan manfaat dan berguna untuk kebutuhan petani?

2. Apa pendapat anda tentang bambu untuk bahan sepedah?

3. Apa menurut anda modularisasi atau kostumasisasi dapat membantu kebutuhan anda?

4. Apakah rupa Greencycle ini cukup menarik untuk anda dan apa yang ada paling suka dari prototype ini?

5. Apakah ada bagian dari prototype ini yang perlu diperbaiki?

Appendix E

Ethics Application Approval

M E M O R A N D U M

Auckland University of Technology Ethics Committee (AUTEC)

To: Leong Yap

From: **Madeline Banda** Executive Secretary, AUTEC

Date: 1 September 2009

Subject: Ethics Application Number 09/163 **Greencycle - A human-centred approach for the analysis, design and evaluation of human powered transportation system concepts for developing and third world countries.**

Dear Leong

Thank you for providing written evidence as requested. I am pleased to advise that it satisfies the points raised by a subcommittee of the Auckland University of Technology Ethics Committee (AUTEC) at their meeting on 23 July 2009 and that I have approved your ethics application. This delegated approval is made in accordance with section 5.3.2.3 of AUTEC's *Applying for Ethics Approval: Guidelines and Procedures* and is subject to endorsement at AUTEC's meeting on 14 September 2009.

Your ethics application is approved for a period of three years until 31 August 2012.

I advise that as part of the ethics approval process, you are required to submit the following to AUTEC:

- A brief annual progress report using form EA2, which is available online through http://www.aut.ac.nz/research/research-ethics. When necessary this form may also be used to request an extension of the approval at least one month prior to its expiry on 31 August 2012;
- A brief report on the status of the project using form EA3, which is available online through http://www.aut.ac.nz/research/research-ethics. This report is to be submitted either when the approval expires on 31 August 2012 or on completion of the project, whichever comes sooner;

It is a condition of approval that AUTEC is notified of any adverse events or if the research does not commence. AUTEC approval needs to be sought for any alteration to the research, including any alteration of or addition to any documents that are provided to participants. You are reminded that, as applicant, you are responsible for ensuring that research undertaken under this approval occurs within the parameters outlined in the approved application.

Please note that AUTEC grants ethical approval only. If you require management approval from an institution or organisation for your research, then you will need to make the arrangements necessary to obtain this. Also, if your research is undertaken within a jurisdiction outside New Zealand, you will need to make the arrangements necessary to meet the legal and ethical requirements that apply within that jurisdiction.

When communicating with us about this application, we ask that you use the application number and study title to enable us to provide you with prompt service. Should you have any further enquiries regarding this matter, you are welcome to contact Charles Grinter, Ethics Coordinator, by email at ethics@aut.ac.nz or by telephone on 921 9999 at extension 8860.

On behalf of the AUTEC and myself, I wish you success with your research and look forward to reading about it in your reports.

Yours sincerely

Madeline Banda

Executive Secretary

Auckland University of Technology Ethics Committee

Cc: Paulus Maringka paulus_mk@hotmail.com. AUTEC Faculty Representative, Design and Cretaive Technologies

Appendix F

Case Studies

These case studies give a more detailed picture of individuals over other methods. This research method provided in-depth insights, details and understanding of the relationship between the bicycle and its users. These findigs have become an integral part of the criteria developed for the Greencycle.

Fig 287. Supriyono profile pict.

Case # 1

Location: Jakarta, Indonesia.

Subject: Supriyono

Age: 32 (2 children)

One of the most interesting types of home-made bicycle is one that provides children's entertainment rides (which has become an icon for lower income people in parts of Indonesia) and it is called "Odong-Odong" by the locals. This type of ride is part bicycle and part Merry-Go-Round. It has four animated plastic rides which up to four children can sit on at any one time. The plastic rides vary from one to another.

Supriyono said no-one actually knew who designed it or where and when the exact date this ingenious ride was created but the locals say they started noticing the Odong-Odong on the streets just after the collapse of the Asian economy in 1998. It seems there is a strong connection between the two, so it is fair to assume that the economic crisis brought about the Odong-Odong's existence. For people in the lower income bracket, the need for supplemental income has forced them to seek new employment opportunities, which in turn also provides the local community with a simple and inexpensive form of entertainment which puts smiles on young faces.

He also said it is rumored that an Indonesian of Chinese descendent constructed eight of these Odong-Odong in his garage and leased each of them for 25,000 rupiahs (about NZ$4) per day. It didn't take long for the Odong-Odong to gain in popularity which resulted in backyard manufacturers starting to produce Odong-Odong to meet the demand. There is no proof the design of the Odong-Odong has ever been registered let alone patented. To buy and own a new one would cost 5,000,000 rupiahs (around NZ$800) but Supriyono could only afford to buy a second hand one which cost him half this amount.

It is roughly constructed using recycled materials - steel tube, bicycle tyres and pedals and any recycled wood sheet that can be found. The main frame is constructed of recycled steel tube which is clearly illustrated by the inconsistency in tube size and quality. Thus, each of these rides must vary slightly depending on the availability of materials when constructed. These include the tyres as some have bicycle tyres while others have motorcycle tyres on them.

The roof houses an old car radio cassette player and two speakers to supply music for the ride while in operation. Generally an old car battery is used as a power supply. A new battery would provide 2-3 days of power depending on how many rides are taken in a day. Most operators use a recycled battery simply for economic reasons but this requires the battery to be charged every night to provide enough power for the next day.

Fig 288. The Odong-Odong

Fig 289. Rohib profile pict.

Case # 2

Location: Jakarta, Indonesia

Name: Rohib

Age: 36 (2 children)

Another form of entertainment ride made of part bicycle and recycled materials is called the “Mini Komedi Puter” (MKP) or “Small Comedy Go-Round”. Just like the Odong-Odong, no-one exactly knows who designed the firstprototype or when and where. The only thing for sure is the Mini Komedi Puter was created after the Odong-Odong. So it is probably safe to assume that the existence of the MKP was inspired by the Odong-Odong.

Rohib built his MKP himself at a cost of 4,000,000 rupiahs (about NZ$650). It would cost him 6,000,000 rupiahs (NZ$1000) to purchase a new MKP from the few places who manufacture it. With pride and a smile on his face he said a new one would be better constructed and be bigger in size however his home-made MKP works just as well as a new one. He collected and bought most of his materials from different fleamarkets and produced a drawing which he handed to a steel welder. After a closer look at the construction it is quite clear that it was built by trial and error. Things didn’t necessarily match up or were not the same size. A piece of wood was used to jam and elevate one wheel to make the ride level. Besides timber and steel tubes, recycled polypropylene sheet is used for the seat walls.

Just like the Odong-Odong, the MKP has two sets of peddles. One peddle to drive the bicycle and the other to turn the Wheel Go-Round. A motorcycle gear and chain is used instead of a bicycle one as it is stronger. He told me some of the bigger sized MKP’s need to have two sets of gears and chains on each side of the wheel to make it easier to peddle and to produce enough force to turn the wheel around. Small diameter motorcycle wheels and tyres are needed to keep the MKP stable on the road. Four steel rods are strategically placed at each corner of the wooden base and can be dropped down to the ground to stabilize the ride while it is in action, just like a big crane with four hydraulic supports.

Fig 290. The Small Comedy Go-Round

Fig 291. Panggih profile pict.

Case # 3

Location: Jakarta, Indonesia

Name: Panggih Sulaiman

Age: 25 (single)

Door to door service is a common practice in parts of Asia. This practice creates jobs and self employment for a great many people. From offering catering and laundry services to a full body massage, it can all be delivered right to your door step. This practice also provides communities in rural areas with services normally only available in bigger towns and cities.

Pangggih Sulaiman has been delivering a tailoring service for eight years in one area of Jakarta city. He said that having a bicycle, which has been modifiedinto a sewing table, enables him to reach a wider area. He estimated that he can cover up to a 10km radius in one day with his home-made mobile tailoring service. That means more customers and more income. There are a few small business who are leasing this modified mobile shop for 15,000 rupiahs a day (about NZ$2.50)

Panggih estimated that he spent 1,500,000 rupiah (about NZ$250.00) to build his own mobile shop. He said he earns up to 50,000 rupiahs a day (about NZ$8.50) which is enough to cover his basic daily needs.

With a similar story to the other two cases, he had to look for all the raw materials. He went to several different “loak” markets (second hand markets) to findthe materials that he needed. However, unlike the other two cases, he didn’t completely build this mobile shop from scratch. He actually used a real bicycle and took out the steering bar and the front fork and connected it to a steel framed plywood box and two motorcycle wheels. He mentioned that there was no problem finding all these materials as there were a few places that sold all the parts he needed - from steel tubes, rods or sheet, timber, second hand bicycle parts etc. An old 1950’s locally made “Butterfly”sewing machine with foot treadle is placed on top of this box which becomes his work table. While at work, Panggih has to jump into the box to operate the foot treadle sewing machine. Two steel rods drop down to the ground and lock to provide stability and support Panggih's body weight.

Another point of interest is that Panggih doesn't use a rubber belt to drive the wheel of his sewing machine. He uses a home-made belt of sewing threads which are rolled and twisted together. This he explained, lasted longer, was cheaper and was more easily replaceable. This shows they have a good knowledge of certain material types and how their lifestyle not only depends on recycled materials but revolves around it.

Fig 292. Tailor on bike

Fig 293. Udin profile pict.

Case # 4

Location: Ciledug, Indonesia

Name: Udin

Age: 34 (1 child)

Like many others in the lower income bracket, selling products door to door is a very common practice on the outskirts of towns and cities in Indonesia. This method of selling not only helps support their own livelihoods but helps these more rural communities by providing services which otherwise would only be available in the city.

“Becak” was the most dominant inner city transportation during the 1950’s through to the 1980’s. When “becak” were banned in most parts of the city in

Fig 294. Udin’s mobile shop

the mid 1980's, the locals turned them into different types of human powered transportation. This not only utilized abandoned ready-made products but also created substitute incomes and employment.

This example is one of the most common types of mobile shop in parts of Jakarta which was modifiedfrom a Becak. Mobile fruit and vegetable shops can be seen everywhere and they go deep into the smaller rural communities and around the outskirts of the city. They buy the fruit and vegetables from city markets and for a small profitthey resell it to the rest of the community who don't have the means or ability to go to town. This is the same for fishand other food produce carts. Each mobile shop, like this one, is transformed or modifid to suit the needs of the individual seller and depending on what type of produce they are selling; there will be slight variations from one to another even though the basic construction is pretty much the same. Almost the entire construction of this cart was of welded steel rods and steel plate. They were rough but built to last.

Fig 295. Ani profile pict.

Case # 5

Location: Jakarta, Indonesia

Name: Ani

Age: 40 (2 children)

Ani uses her bicycle to sell traditional sweet cakes and precooked food in the suburbs of Jakarta. Her mother used to do it for years by walking from suburb to suburb on the same route as Ani does today. Ani leaves at 6 am from Tanggerang (about 80km outside of Jakarta) by public transport to Jakarta to her brother's place where she keeps her bicycle.

She buys the goods she needs from the local market before doing her round. She said that the food will have been mostly all sold by mid-day. It seems she is

Fig 296. Ani's bicycle with costumed rack .

only doing this to supplement her main income. She carries only enough goods to ensure it is all sold within half a day so there's no need for her to have extra space on her bicycle to carry lots of items.

Her brother helped her to construct the extra frame to hold the two baskets which is attached onto the passenger seat by two screws. There is evidence that some work has been put into this bicycle as it was properly done and well constructed. There is an extra basket at the front of the bicycle but it is something that would usually come with the bike or could be purchased from a bike accessories shop.

The rear support bracket is very simple but well made. It is made of a steel rod and plate frame. Two different old worn plastic baskets are used as compartments to keep the food on each side of the bike. The basket can be taken out and used as a carry basket. Torn and faded with home made handles, these baskets look like they are older than the bike. Grocery plastic bags are also used to carry excess product. Unlike the others, her bicycle is a relatively new model.

Fig 297. Warsim profile pict.

Case # 6

Location: Kerawang, Indonesia

Name: Warsim

Age: 48 (3 children)

Warsim works in the padi fieldsat harvest time for land owners of neighboring farms. He moves from farm to farm depending on their harvest times. Some months in order to continuing working, he needs to ride up to 40km to reach his destination. While he gets paid for his daily labouring, he is also allowed to collect excess padi (rice) left on the ground after harvesting. He can have all the excess padi he can findand takes as much as his bicycle can carry. He said on a good day he can carry up to 200kg of padi. In an average day however, he collects around 100kg of padi which he sells for a small profit in the neighboring villages to supplement his income.

With a bigger load on he sometimes needs to push his bike when returning home. When asked why he didn't use a trailer, he said it was illegal to have a trailer since becak's were banned in the 1980's. The local police or traffic cops issue citation's for any breach of the law which in most cases is resolved when a small bribe is paid. This statement was confirmed by Warsim's riding partner.

He said he bought his bike 30 years ago when he was still a single man. It has a worn out label at the front which says "Phoenix". This is the most common bicycle you will findand they are used as a "work horse" in parts of Indonesia simply for its strength and good construction. It can hold up to 500kg of weight where newer bicycles can only take a maximum 200kg load before it starts to crumble.

A home-made wooden tray is placed at the rear on top of the passenger seat, to give a wider base to put his sack of padi. His front wheel is turned at a 90 degree angle to stabilize his bike when stationery. Worn out sandals hang from the front handle bars. A thick bamboo stick that he used to carry his sacks of padi with, now acts as a stand to hold his bike upright.

The Phoenix was made in China and imported to Indonesia in the 1960's. It is a very well constructed bike and built using heavy steel. It was built to last and it has a few features which modern bicycles don't have such as an extra fork at the front to reinforce the front wheel in case the main fork gets damaged. The rear passenger seat also has a double frame on each side connected to the center of the wheel to accommodate heavy loads. The only part he has to purchase to keep his bike running is a set of tyres. 'I always buy a new set of tyres' he said because it is the most basic part that keeps his bike operational.

Fig 298. Warsim with his bicycle.

Fig 299. Iman profile pict.

Case # 7

Location: Kerawang, Indonesia

Name: Iman

Age: 45 (4 children)

Iman sells cold water bottles to farmers who work in the rice farms. He lives at a village called “Cimahi” and travels about 20km a day. He leaves the house at 5.30am and returns home at 7.00pm. About fiveyears ago he used to be a bicycle taxi (ojek) before he started selling cold water bottles. He carries 50 bottles of water a day in his 20 litre plastic paint buckets, which he then sells for 2,000 rupiah per bottle (around NZ30 cents). These two 20 litre plastic paint buckets can only hold 50 water bottles.

Fig 300. Selling water on bicycle

He bought his second-hand “Bango” (brand) bicycle 30 years ago for 2,500,000 rupiah (around NZ$40). He made very basic modificationsto the bike out of scrap timber to hold the two plastic buckets on each side of the bike. It has high handle bars from a Schwinn kid’s bike which was popular back in the 1970’s, probably because it is more comfortable when riding long distances. When asked why he didn’t use a trailer to carry more water bottles, he simply answered that he couldn’t afford one.

Fig 301. High handlebar.

Fig 302. Azhar profile pict.

Case # 8

Location: Tangerang, Indonesia

Name: Azhar

Age: 48 (6 children, 1 grandchild)

Azhar has been a fruit hawker for the last 25 years and makes between 50,000 to 100,000 rupiahs (NZ$17) on a good day. He lives in the village called Kemiri in Tangerang province, about 30km from the street spot where he trades daily in Jakarta. He said he only sees his family once a week. He buys his fruit early in the morning from a market close to his village then rides to town where he sells his fruit. In the past he had to travel on his bicycle over 66km to Bekasi to buy his fruit.

Fig 303. Selling rambutan on the street.

He bought his 1960's Chinese made bike for 3,000,000 rupiah (NZ$500). The back seat has been reinforced with a welded rod frame constructed to take the extra load weight. A wooden brace tied with used inner tube tyres holds two home-made woven bamboo baskets lined on the inside with used plastic rice sacks. These sacks are where he stores the fruit. These bamboo baskets cost him 140,000 rupiahs (NZ$25) and 10,000 rupiahs (NZ$17) for other materials to complete this cargo. With the detachable bamboo baskets full with fruit and tied to the back seat, he carries up to a 100kg load. Bright coloured paint is marked on the rear frame of the bamboo baskets to warn oncoming motorists of his presence at night.

Fig 304. The detachable bamboo baskets.

Fig 305. Yuri profile pict.

Case # 9

Location: Jakarta, Indonesia

Subject: Bicycle Enthusiast

Name: Yuri Sofjan

Age: 46

Yuri is an Indonesian business man who has been a bicycle enthusiast since he was very young and lives in the capital city of Indonesia. Over 10 million people live in Jakarta alone and this causes serious trafficjams. He collects hard-to-findbicycle parts from the past which have now become very valuable to bicycle enthusiasts around the world.

Over the years, he has owned some of the most expensive bicycles available on the market. Currently he rides his pride and joy – a 2002 Colnago C40 Bstay, which cost him close to NZ$10,000. He also owns a 1991 Colnago bike frame (the same bicycle was raced and won in the 1992 Tour de France) which is part of his collection purchased for NZ$1,000. He also owns a 1932 Dutch made Fonger bike in original condition. As an avid enthusiast, he explained how prized these old bicycles were for bicycle collectors and they are highly sort after. There are even clubs for owners of these antique bicycles. As the biggest proportion of the Indonesian population, low income earners have a daily income of approximately

Fig 306. The 2002 Colnago C40 Bstay

Fig 307. The1932 Dutch made ‘Fonger’ bike

NZ60 cents so bicycles at these prices are inconceivable and unobtainable to them.

However, Yuri became a good contact source for this research study by providing an understanding of the psyche behind the bicycle craze in Indonesia which played a big role in pushing up bicycle prices there. To ride a bicycle in public in Jakarta is a hazardous thing to do, not only due to high crime levels but also from trafficcongestion and pollution.

A bicycle race track was specially built in Jakarta for these elite bicycle owners so they can ride their bicycles anytime for a small entry fee. This track has become more popular every year; its popularity being contributed to by health awareness campaigns being promoted by local government and bicycle manufacturers.

Yuri said he tries to go to this track almost every afternoon with his other fellow bicycle enthusiasts because of their genuine love affair with bicycles. Going to this track has become a ritual for many people in Jakarta, while for others it's simply a place to get away from their busy lifestyle and get a daily dose of exercise. However, he also said that going to this bicycle track has become a social event and trendy for many people - a chance to show off their latest gear and expensive customized bikes. For some of these high income earners, it is a way to show their wealth status and how successful they are in business, which has changed the focus of many bicycle manufacturers from producing practical everyday bicycles to more specialized and high-end product ranges.

Fig 308. The 1991 Colnago frame.

Fig 309.Yuri's vintage bicycle parts collection

Fig 310. Trimanto profile pict.

Case # 10

Location: Jakarta, Indonesia

Subject: Bicycle manufacturer & dealer

Name: Trimanto (head designer)

Age: 35 (1 child)

Trimanto has worked as the head bicycle designer for the company for 15 years. He graduated as a graphic designer from a local university in Jakarta. He admitted that he only managed to get his job with the company because of his technical experience rather than for his graphic design qualification.He said he gained a reputation as a bicycle designer after he built the "sepeda gantung" (hanging bicycle) for Taman Mini Indonesia (national park) and proudly pointed to a framed picture on the wall. The company started as a small shop in the 1960's selling imported bicycle parts from China, India and Taiwan for becaks, bicycles and pushcarts in Jakarta. In the 1970's, they started to import bicycles made in Taiwan and India. By the 1980's the company became a legitimate manufacturer called PT Bintang Timur. However, it took more than ten years before they started producing their own bicycle in 1991. At the beginning, the company struggled to compete with imported bicycles made in China which were selling on the local

Fig 311. The United bike Gallery in JakartaFig

Fig 312. The photo of Sepeda gantung

market at 20% cheaper. Only with superior quality and educating the public about their product, have they managed to secure their place in the bicycle market. Trimanto said their current annual production has reached 400,000 units.

In 2003 the company opened a manufacturing plant in Ningbo, China where they are producing up to 600,000 units annually. These bicycles are more economical and slightly lower in quality however they are solely for the export market for what they consider as a more compliant market, countries such as India, Russia and Africa. The bicycles they produce in Indonesia are of a higher quality and are exported to European countries like Italy, Spain, Germany, Holland and Canada.

Trimanto explained the company is very active in developing their product. Consumer feed back is used to monitor the quality of their products. National athletes are their main focus group, not only as a main source for ideas but also to test their prototypes before going into full production. In 2004, the company started to produce luxury bikes for the high end market. These bikes started with a 6,000,000 rupiah (NZ$1000) price tag. In 2007, Trimanto said 2000 units were sold to local bicycle enthusiasts. Today the company is producing 50 different types of bicycles from BMX, racing and mountain bikes through to children's bikes with the price ranging from 400,000 rupiahs (NZ$67) up to 40,000,000 rupiahs (NZ $67,000) per unit.

When asked about a work-horse type bike for people in the lower income bracket, he said the company once explored this idea and made an attempt to produce a work-bike but it only sold in small numbers. When asked about the reason for this, he simply answered it was too costly to build such a bicycle where only a small profitcan be made. However, they are producing bicycles with a vintage look, borrowing the aesthetic from bicycles made pre-70's because it is currently trendy and in high demand. Owning one of these vintage bicycles is sought after for their high value and as a status symbol.

Fig 313. A Cruiser made by United

Fig 314. Ahmad profile pict

Case # 11

Location: Cibinong, Indonesia

Subject: Bicycle manufacturer

Name: Ahmad (R&D and QC)

Age: 36 (no children)

Ahmad has been working for the company for 14 years starting on the assembly lines. With years of experience with the company, he has now been promoted to the role of quality controller and he is also in charge of the company's research and development department. The initial idea of visiting this company was to observe and learn about the local production line and to see if the company's operations included or considered sustainable practice. Unfortunately, access to the production floorwas declined but an interview with Ahmad was granted under the supervision of a senior staff member.

Ahmad explained that the company manufactured and built bicycles under contract to another company. They also imported parts from China and Taiwan and sold bicycles locally assembled in Indonesia. The company's success has been contributed to by the Indonesian government who are trying to promote

Fig 315. Mountain bicycles produced for United Bike

healthy living and reducing carbon emissions by closing the main street of Jakarta once a month from motorized vehicles so bicycle owners can roam freely.

The company also used to manufacture bicycle tyres but ceased tyre production because of the booming motorcycle industry. Threatened by the popularity of the bicycle, the motorcycle industry fought back by making the purchase of a motorcycle easy by allowing buyers to pay on credit. A motorcycle can be ridden out of a dealer showroom by only putting down a 250,000 rupiah (NZ$40) deposit. Thus buying a motorcycle became much easier and cheaper than a bicycle.

Fig 316. Female bicycles with basket

Fig 317. The working horse bicycles

Appendix G

Interview transcript of New Zealand Bamboo Grower (August 2nd, 2009)

Transcript interview: Bamboo Grower
Oratia, New Zealand, August 2, 2009

INTERVIEWER: How easy can bamboo be reproduced?
INTERVIEWEE: By rhizome division - ease will depend on the tools needed to produce a maximum of 6 plants per stem then grow on into multiple stems. Small plants can be divided very quickly from its rhizomes. Culm cuttings and also aerial roots of many species, particularly Dendrocalamus species can be grown successfully in tropical countries. Tissue culture could be the best way of multiplying bamboo initially but it takes a number of years to establish into taller culms for quick results in the NZ climate unless material is constantly divided there after.

INTERVIEWER: What sort of natural treatment/process is needed to preserve or to make it last?
INTERVIEWEE: So far, only borax with straightening in the same process. Otherwise, harvesting in the cool season, storing to dry, smoking or kiln drying to remove sap and moisture extends outdoor life. Toxic methods have been trialed here. Insects and moulds will cause more problems when harvested during the growing season.

INTERVIEWER: How fast do the bamboos grow?
INTERVIEWEE: Preparation, moisture, temperature are all relevant. Temperate runners are more likely to be consistently fast but have a medium period, 2 months, to dry and leaf. In average conditions, cultivated bamboo above ground can put on between 0.6m to 2.4m or more in height on new stems. In ground that can as much as double, depending on the species and former conditions. They proliferate in average conditions by 2 stems per existing culms, until those are spent. On average, culming bamboos have 6 buds on each rhizome and suckering bamboos may realize 1 per 300mm per annum. Suckering bamboos may realize approx. up to 2m length of new culms per annum in young plantations - they slow down in dry, old and shaded plantations. Removing old culms will increase the number of new culms emerging. Soil management is important.

INTERVIEWER: When is the ideal time to harvest the bamboo? (How old is it before it can be harvested to get the best quality bamboo?)
INTERVIEWEE: Depends on the end use. Pulp can be harvested at three to four years. Five to six years for lignifications of the whole pole for floor and panel fiber.

INTERVIEWER: What is considered an unsuitable environment for growing bamboo?
INTERVIEWEE: Depends on what the end use is - bamboo will grow in most soils. Less suitable - too dry and shallow or too deep in certain materials such as phosphate rich sawdust, too sandy, too peaty although more water and peat soils can be adjusted with raised planting, adding clays or other silica elements. A 'poor' environment can produce the best quality stakes but perhaps less numbers – fine scoria is not the best unless adjustments are made using peat, etc. An ideal soil is a clay base or sandstone. Ash topsoil with plenty of mulch for fiber increases the nitrogen content for edible bamboo with 2m annual rainfall or plenty of mulch in the soil with 1m annual rainfall. Each site can be adjusted accordingly.

INTERVIEWER: What is the fastest growing type of bamboo there is?
INTERVIEWEE: Those from 1 to 2 year old clump root stocks grow biggest. For reliability the suckering species will grow to its optimum because the rhizome can move to express soil quality. In ideal conditions, clumping bamboos will perform well also -

moisture, plenty of mulch, humus and manure. Again, management makes a difference and can be done by simple methods such as fertigation or spray manuring.

INTERVIEWER: Would the growth speed of bamboo affect the property (strength) of the bamboo it self?
INTERVIEWEE: Yes, excess nitrates can cause weakness of the culms rigidity vs. foliar flush. Soil quality and the length of time the bamboo has to produce the standard required, ideally 5 to 6 years for timber strength is important, clay bases, pumice and scoria all help with strength. For some applications - a minimum 4 years - they may produce less numbers of a required strength, particularly the giant bamboos if the expected maturation period is short but with nutrient management this could vary. Species selection is also important. e.g. stone bamboo. P. angusta is always stone bamboo, as is iron bamboo D. strictus. Rotational harvesting, selective thinning, marked poles will achieve best quota.

INTERVIEWER: What is the strongest type of bamboo there is?
INTERVIEWEE: Of temperate species for cooler areas, i.e. min. temp of 5 deg.C or less – Phyllostachys pubescens for size and thickness of wall, of culming bamboos it will probably be Dendrocalamus strictus, (iron bamboo), Guadua angustifolia or other variety.

INTERVIEWER: What is the smallest size/diameter of bamboo?
INTERVIEWEE: Very small is 2mm of bush bamboo species. For plantation poles the diameter can be from 18mm.

INTERVIEWER: What is the biggest size/diameter of bamboo?
INTERVIEWEE: In NZ it is 160mm so far. Again cultivation can and does make a difference to all species. In Indonesia the diameter can be up to 250mm.

INTERVIEWER: Property of the bamboo?
INTERVIEWEE: High silica content for tough epidermis and sclerenchymal bundling in the outer structural walls for compressive strength ranging between 47.0 and 62.8 N/mm^2 on Phyllostachys pubescens. Weak lateral bonds vary between species. Some culming bamboos, Bambusa oldhami may have more phloem fibers higher at nodes possibly to support faster maturation in humid to dry tropics and culms movement variations. Compression strength strong also but from the naked eye the percentage of cellulose fibers appears greater, the epidermal layers are thin. Tensile strength greater weight for weight than steel. See IL32. (Toenges. 2001) Christoph Toenges (2001)
http://www-users.rwth- aachen.de/Christoph.Toenges/pagesEN/properties.html. Retrieved on: 7 May 09

INTERVIEWER: Does the size/diameter affect the property/strength of the bamboo? (Does the bigger size mean it's stronger?)
INTERVIEWEE: Yes, per compression strength. Weight for weight comparisons is available.

INTERVIEWER: How do you stop bamboo from degrading? (After it has been harvested) What is the most natural process to preserve bamboo? (After it has been harvested)
INTERVIEWEE: Oil treating at high temps if lignin is preferred.

INTERVIEWER: How would you preserve the natural color of bamboo? (After it has been harvested)
INTERVIEWEE: A tricky one which as I mentioned was a well kept secret involving additives to the growing bamboo. Should be cracked soon though with a bit of thought.

INTERVIEWER: Do bamboos need a drying process/drying time before it can be used?
INTERVIEWEE: 1 to 3 months.

INTERVIEWER: What is the shrinkage rate after it has been harvested?
INTERVIEWEE: Less than 5% if the right age.

Appendix G.1

Interview transcript of Expert no.1 (August 2nd, 2009)

Transcript interview: Expert no.1 (Industrial designer/ Engineer)
Auckland , New Zealand , October 7, 2009

INTERVIEWER: So, which one do you think is the better one?
INTERVIEWEE: I think, Number 2; just the front part which has a common bracket, so whatever they got they can always mount it to. Things like this might get too complicated and makes it more difficult to load up. A simple Bungee cord is probably the easier and yet universal way to go. Because number 1 is quite limiting to what they can do; and if it do damage to it, they can't fix it. The more moving parts you got, it might restricts the use of it or get in the way.

INTERVIEWER: As you know, the whole idea here is to improve the transportation of human culture for the Asians. Do you think by looking at how much they can carry could improve the issue or do you think it's more of the opposite? As I explained, this project is to improve on what they have. But I don't think there's much to improve on bicycle structure, because I think that bicycle is pretty much perfect. So I'm just looking at different ways to improve it; one thing I look at is trying to improve the usability of it. This is the reason of why I'm looking at all these different options here.
INTERVIEWEE: If you are targeting farmers, more people have to carry stuff. This could be like a tractor, they have a universal joint at the back where they plug in their harvester and put in their trailer onto it so they're multifunctional. So that's why you need something common to bolt onto, so if it was to be something in the front there, and you can just have different options which maybe just clip on this for one day or clip on something else, because some of your flat ones are quite good to carry stuff like that. Thus they aren't going to be doing the same thing every day.

INTERVIEWER: That is the purpose of this, whatever the solution is, it should work for the others too. So hopefully the people who are selling vegetables can still use it too. And maybe one day they want to have a bicycle as a one piece bicycle; they don't want any bits and pieces on it. Because at the moment we are looking at it now, they look like utility bicycle rather than carrying people. This is more of carrying items. So I think that's where I'm going with this to create something that could be personalized and put it together to suit their needs.
INTERVIEWEE: I think what you got is quite good because they have lots of different functions and every function just clips onto the main part of the bike. Like this is one of the trailers, they can carry lots of stuff once a week to town, but for the rest of the time they cannot do the trailer at the back. And it becomes annoying and get in the way.

INTERVIEWER: Because I think the final one would be a combination, and I don't think I can do all these options.
INTERVIEWEE: Some of your options are doubling over a little bit. 6, 9 and 8 have somewhat similar functionality wise. 7 and the 10 is almost the same.

INTERVIEWER: Basically, what I'm trying to do is to look at different ways mechanically on how it works rather than how it functions, because at the moment I'm looking for the best way to build this. I'm looking for a system that can be personalized that means when they don't use it they can just fold it, so they don't become a hinder to them. So they can just fold them flat. They can pull it out or undo it when they need it. And that's the reason why I'm exploring these different things. But notice like number 5 is more similar to the trailer number 4 but this is the wheels actually follow the weight. So this is the reason why probably looking at this of more for village emergency, ambulance or a doctor or midwife (Just some concepts). But again it seems to get more complex to build because I'm still looking at the way they can build it quite cheaply and also the materials too. This is the reason why it's all straight because keeping in mind that probably the material they have

will not probably be fabricated, it's just going to be pre straight wood, bamboo or tubeless steel. That means they don't need a big set up to make it. That is why I keep it simple.
INTERVIEWEE: It definitely mean that adding extra wheel means you can carry extra load and more stable.

INTERVIEWER: Part of the problem when I did my interview in Indonesia was about why not pulling out a trailer? But they said that if they were to do that, they need to pay a tax, because in China in the 70s they still paying tax just like cars for bicycles, So I'm not really sure but I'm going to go back and confirm that whether the trailer will cost extra for these people or not. This is the reason of why I did what I did, because I don't want it to be just a trailer. They have extra wheel but also they can fold it and become bicycle. This is the thing I will confirm when I go back to Indonesia, because if the trailer is possible, then it means it will become a better solution. But at the moment that's what I've heard the last time that by carrying trailer they get stopped and got to pay fine. So, I'm basically looking at these concepts as the usability and functionality of it. But I guess basically when I was producing these concepts; I have in mind of what the usability of it would be and how it functions for different users. This is the reason why I did these concepts because now, I need to look at it and simplify them. You're probably right that number 3 & 6 9 10 and even 7 they do the same thing but different system. Number 11 is different but I don't consider it to be just a simple thing. So it is double I think, and I'm looking basically on what you think about the best system is, because I need to simplify.
INTERVIEWEE: I think whatever folds up as flat as possible when they're not in use is the best. So it's not a hinder.

INTERVIEWER: I'm thinking of actually taking the whole thing off when they don't need it. (Something that you put together only when you need it).
INTERVIEWEE: So another two at the front, just like number 2 at the front is fix structure and then just like number 3 as it goes down it just clips on onto the front. Because you don't know if they will be carrying heavy order like water bottles or something to sit on a flat surface just like the ambulance number 5. It needs a flat tray because I think it could be quite important. But also number 5 that can sell their product in there. And without stand behind the bike and have the product behind already.

INTERVIEWER: I think it can be of two different options really, this is more specific needs, looking at midwife doctor, fire engine, ambulance, more of a specific need. If I can do them all in one system, that can be good but if I don't than that's still okay. I think I'm looking at more of people who use the bicycles as a moving horse to carry stuff.
INTERVIEWEE: I think number 3 is possibly the best one but you don't need those extra wings sticking up because they may get in the way. And that same system can go in the front and at the back. So that's probably what you want as well, something flat. You want it to be leveled and preferably the same system front and back. So they can load up equally.

INTERVIEWER: I suppose.
INTERVIEWEE: Number 4 can carry lots of stuff and the extra trailer.

INTERVIEWER: I suppose it depends on what they're carrying as well, because number 8 is the simplest and cheapest option. Because it looks like it's something that's cheap enough to build. But it also depends on what sort of stuff they carry. If you go with hay, paddies' or something like that, then they will probably be okay.
INTERVIEWEE: But if you got a lot of weight into it, it would be quite difficult to hold the bike. To put it on and try to lift it up around, it might be too difficult. You need to adjust it between the fabrics costs you six sides at the moment but you will never know what you will be carrying.

INTERVIEWER: It somewhat limits on what you can carry. Everything here got its limit and it's probably why you can carry so much.
INTERVIEWEE: You will probably go well with hooks since you only got two adjustments there, so it will be better off with more adjustments. Just the two of them.

INTERVIEWER: Because the thing with number 8 is that you know your minimum and also your maximum weight.
INTERVIEWEE: They most likely to not carry lots of stuff in sacks.

INTERVIEWER: But you're right, it would probably quite difficult for them to load, because you have to pull at the same time. You can't just drop it on top.
INTERVIEWEE: Because when you lift it up, the weight is going to push the back. And it will be a problem, unless you have a stand that they can drop down to the ground. Like a much wider stand that they can load it up and stand on them to get the balance after that.

INTERVIEWER: I suppose number 9 you can still use bungee cords. You can use it like number 2. You can use it pretty similar. The only differences are the number 4 they have wheels. Otherwise they can work the same way. It doesn't go all the way back. But I guess you can use 4 like you use number 2 so you can tie the bungee cord to hold them up. So they work as a guard too. But the only problem with that is it becomes a trailer. Do you see any problem in this? Would it be hard to steer?
You need a 1 point so they can sit on plus all the loads on there, so it will lift your bike up on the air. So you need to bring the back of the axel right up to the centre here. And that will push all the weight back on the wheel over the front of the wheel and not tip it.

INTERVIEWER: That the concern I have with number 4 as well, the amount of weight will probably lift the front part.
INTERVIEWEE: But most of these you got them quite high and you can actually go quite low.

INTERVIEWER: Yea, I think most of them are going to go quite lower than this. This is just for purpose of models
INTERVIEWEE: If it's lower you can hold more stuff and you got lower centre of gravity so it not going to tip over. And if it does then it means it too heavy to lift it back up again. Are they going to drive on flat surfaces?

INTERVIEWER: Yeah I think its still probably be why I still did bicycle is because the conditions of the road. And they're not big enough for cars. If you imagine the paddy field, they only have footpath. They have to go somewhere narrow. That's why bicycle is still one of the best transports for them because it's easy enough for them to walk with. They don't even have to ride it. They can just walk with it. That's what they do, put a lot of stuff on it and jus walk it because they can't ride it. I suppose because bicycle are not meant to carry lots of stuff. The reason why I'm doing this I suppose is how looking at these can actually increase the amount of item they can carry (improve). And this bicycle is rather than changing the structure of this bicycle is looking for ways so it can be customized, personalized, take it on and off when you don't need them. Or even just to fit what you need (the amount you can carry). I think the most stuff they carry is on the harvest time (When they need huge amount of space so they can carry them). I think from here on, looking at the best way or system I can come up with because then I can work backwards and actually say okay now what type of connections do I need if I choose to use natural material as the main material(Bamboo or timber or whatever). I have to actually look at them and see how I can connect them so they can add the system so they can carry more items.

INTERVIEWEE: I think most o the time they just use whatever resources they can find or have.

INTERVIEWER: I mean they're doing that at the moment. Like bicycles at the moment are made out of what resources they can get so it's not by adding functions of it. But it's not in the best of what they know how. (Because of the limitation)
INTERVIEWEE: I guess if it's in bamboo or straws, it will be quite lightweight.

INTERVIEWER: The other question is actually better if it made of steel? So it would last forever?
INTERVIEWEE: I guess if you do make no 2 smaller, basically to just cover the wheel so nothing could fall on to the wheel and nothing can stop the wheel .Then you can just put bamboo across there and there and since bamboo are quite strong, they can just hang them over the bars. I think a bag system would be the cheapest and the best way to carry stuff. And they can fold up, so they're basically nothing. Maybe it can be just with hooks and bags, so the bags can hook over the bamboo or something like that. If there's bamboo sticks sticking out, they can hang about. Just like number 8, you got a fold down wings, instead of the hinge down at the bottom; you can hinge it down from the top. From number 8 you got things folding down, maybe you can have it fold other ways too.
INTERVIEWER: back to the woven baskets is another thing I'm looking at, because it's something they can create by themselves, or something they can get from the local craftsmen's.
INTERVIEWEE: Yes, because it's basically an essential shelter and clothes which means it universal all over the world.

INTERVIEWER: So the only problem with the baskets is the limited spacing into how big the baskets are going to be. Is that the only downfall of it?
INTERVIEWEE: Well you also got bags to think of. Like the new recyclable ones, you can get it quite big with double stitching.

INTERVIEWER: But I wonder if those sorts of things are available in Indonesia ... and how they will be able to obtain those sorts of things.
INTERVIEWEE: Well they got rice sacks and they're pretty strong.

INTERVIEWER: Yea, I think they're made from coconut fiber sort of things.
INTERVIEWEE: Yeah I think that stuff is quite cheap too.

INTERVIEWER: Yeah and it would probably be easier to construct too.
INTERVIEWEE: As long as you have a cover over the wheel, so you got something that covers it from grinding against the wheel.

INTERVIEWER: I think we still need the frame to hook it up onto sand stuff. Probably it's another kind of solution I can look at. Because what I'm looking at now is about giving them space on putting the stuffs that they want onto it.
INTERVIEWEE: Because the loading of the bike, they will most likely go onto a bag before it goes onto the bike; so most stuffs are going to be pre packed already which basically means it will be just resting on it.

INTERVIEWER: Yeah, I guess bag is another solution with a simple frame.
INTERVIEWEE: What you got on number 8, the bags can already hook onto these hooks.

INTERVIEWER: Well number 10 is probably closer to what we're looking for, thinking of a bag system kind.

INTERVIEWEE: Yeah, I guess it is the best way to have a frame that can basically hang bags off.

INTERVIEWER: The thing is with the bag, is that you can't go high.
INTERVIEWEE: But if you have a frame, you can start stacking it, and go higher. Because the bag is going to droop anyway, But like what we talked about at number 3, where the bags can just rest on a shelf at the bottom. So it's a combination of these two.

INTERVIEWER: So you still have it fold up when you don't need it?
INTERVIEWEE: Yeah I think it will be the main criteria to fold up.
INTERVIEWER: So you mean by having a flat area and also a part where you can just hook bags onto it?
INTERVIEWEE: Yes, number 7 could be adapted as well.

INTERVIEWER: Number 7 can be stronger in a sense, but I'm not sure, but it is a simpler structure; whereas the others are a little bit more complex because it has slider function to it.
INTERVIEWEE: Yeah, it's quite good how you can put bags on, but u still have this back part for the seating area so you can still put stuff hanging down as well. So number 7 can have a cloth.

INTERVIEWER: Yeah, so you can basically fold it.
INTERVIEWEE: But, this part on number 7 doesn't have to be on the bottom. You can put more stuff if it was on top.

INTERVIEWER: But you are going to have something to hold them down though.
INTERVIEWEE: Yeah, you need something to push it up.

INTERVIEWER: Maybe we could look at it as 2 different systems. One can be of a flat deck to actually put stuff. And the other system can be like a frame you can add on to hook stuff. Maybe it can be just 2 things to integrate, so one area is to stack the boxes as high as u want. And the other series is to hook some of the bags off. I think it could be the most appropriate combination. Because I'm looking of which ones can combine into the most appropriate result, this is the reason why I came up with different things and look at them and try to combine them. This way I can start working at the system and connection to design. I suppose bag and baskets is not going to be too hard to obtain, because one of the things I'm trying to do is to create more jobs for them too. So there must be some with good craftsmanship people to woven the basket and stuff.
INTERVIEWEE: I mean these methods are still universal to create baskets or bags. If we look at number 3, how it just fold down, maybe we need another system where it can just fold up. So that means you can rest it off on top, or if the bars are quite high, you can hang hooks onto them. You can have attachments on the bars and hang stuff onto it.

INTERVIEWER: The only thing is that, if they got stuff to stack up high enough, it all be difficult to hook after that.
INTERVIEWEE: Yeah it depends on how much they put; if you got the same system on front and back, that's probably more than they can carry already.

INTERVIEWER: Some of them really push on how much they can carry. Because 1 bike does one job, and they use the old bicycle because they're much heavier and longer lasting and new bicycle won't do it. They push it by putting a lot of things to it, but the new ones won't do it.
INTERVIEWEE: Just number 3, if you put another wheel here and they could fold up.

INTERVIEWER: I don't think they have to be a large wheel; they can be small wheels to lower the deck; because it will be like number 5.
INTERVIEWEE: You don't want too small of wheels too, or else it won't ride as well.

INTERVIEWER: Another wheel will only take the load off, not much about the riding, but it also stabilize it. So you can put more weights too. But we still don't know whether they can have the wheel due to the tax.
INTERVIEWEE: But can you have a system where you clock two bikes together and they ride in unison and they can have the load.

INTERVIEWER: They could be; if these collectors are smart enough then hopefully they can do that.
INTERVIEWEE: Yeah and you need some kind of linkage to do that.

INTERVIEWER: But I think if you can lock the frame, always going to be parallel with the front wheels because they going to have to walk with the bicycles anyway or either rides it. You got 2 people who can ride it. That's not a bad solution either. So the key is having the frame as a system that I'm trying to work out.
INTERVIEWEE: I think if you have the steering at the front and you got two locks together then you need to go backwards. So it's not the wheels that won't go like that but if you go backwards it might follow each other. But I'm not too sure either. But the other bike doesn't need to have a rider on it.

INTERVIEWER: As long as you can lock the steering wheel, I think you can always go straight up. It won't be too difficult to do that.
INTERVIEWEE: If you have this common mounting on both of them, then you can get quite a linkage that's going to be the same.

INTERVIEWER: Yeah you need to still turn left and right
INTERVIEWEE: But if you turn with one wheel, the linkage will turn both of them like a car; because you probably need the linkage to lock the frame together with a same distance with at least 3 points to stabilize.

INTERVIEWER: The only problem is only the steering part which could be tricky.
INTERVIEWEE: Unless you go backwards and it doesn't really matter.

INTERVIEWER: But you still need to steer them.
INTERVIEWEE: Yeah, but you only need to steer the one and the others will follow.

INTERVIEWER: Something to look at too is the fact they always work in pairs too. They always have two bikes. Maybe it's not such a bad idea to connect the two. Because they still have to walk with it. Well hopefully we can find a solution so they can ride it not walk with it. The reason of walking is because they don't have any more room to sit on it. They maximize the use of bike with the stuff. That's why I'm hoping my solution could have them ride on the bike. It is possible to ride two together, because they don't ride fast.
INTERVIEWEE: But if they do have two bikes, they can load up the seat and push from the back like supermarkets. Walk between the two wheels. And then once they have unloaded it, you need to chuck one of the bike over...if one person pushes two bikes with lots of loads on them, the other bike needs to sit on top of the other bike while they ride the bike all the way home.

INTERVIEWER: Yeah that could be another solution to look at. Connect them together....because all we need now is a frame that can clip together.

INTERVIEWEE: Yeah as long as they have the same distance. And you got at least three parts of them so they can clip on top like a trolley. A tandem is a double length bike and that does make it harder to ride and it's not useful for the rest of the time.

INTERVIEWER: Because one of the solutions was one guy having a longer farm attached to the main frame, but you take the wheels to increase the back part of it. So they hook it up to increase the chain part of it. They're actually already working in Australia and being used in Africa at the moment. It's fixed. Still the basic idea of it is to just expand the back part and have stuff put on top of it.
INTERVIEWEE: Once they do that, it won't be practical.

INTERVIEWER: One of the thing I tried to avoid is to can a build their bicycle, and I don't think we can do that either. I think it's quite precious to them as well.
INTERVIEWEE: Plus as a customer it's going to be hard to service or maintain; As long as you have two identical bikes, and pull the seats off and drop in a bar that comes up along and down and have another seat in the middle where you pedal.

INTERVIEWER: I think all this moving parts is going to be difficult. Keeping it simple would be the best.
INTERVIEWEE: Something like number 3, just take it off and clip it over here and the bottom, will be multifunctional. And keep the distances the same so it could go sideways. You just basically hang bags to carry. For number 9, you can still hang bags off from there to there and put more stuff onto there. If it was leveled you have a flat place to put more stuff.

INTERVIEWER: I think some of them are quite similar because it basically folds very flat. Is there any other way that the bike can be improved other than this way? Maybe to increase the amount they can carry?
INTERVIEWEE: If you can just convert them into vehicles that carry a lot of stuff likes trucks with lots of wheel.

INTERVIEWER: Yes, but if we start doing that sort of stuff it means we are trying to start cannibalizing their bikes and it's the thing that concerns me.
INTERVIEWEE: Yeah because like its unlimited on the things to put onto the bike, but if there is no man power to move it then threes no point on doing it.

INTERVIEWER: True, because they can only carry as much as they can handle.
INTERVIEWEE: But actually, if you can just have one main bike and one more going backwards, then you're not relying on the back wheels so it doesn't have to be tied down.

INTERVIEWER: that's going to be quite tricky though, unless you offset them...
INTERVIEWEE: Yeah if you turn one way, the other one will just follow.

INTERVIEWER: Yeah, it may be possible to do it this way.
INTERVIEWEE: You can basically use the other bike as a trailer.

INTERVIEWER: There is another thing is that this is not something cheap for them to get it either. They will use it as 2 separate bicycles not as a mounting system together. It's not a bad idea because it's something I haven't thought of, having 2 working together. Because having two together means there's more amount of stuff to carry instead of one carrying bike.
INTERVIEWEE: Yes, because probably one bike you can only carry one item; whereas two bikes can probably carry three.

INTERVIEWER: So basically if I want to do it like this, I just have to look at the ways to connect the frames and such. I don't think it will too much different from what I'm doing at the moment
INTERVIEWEE: The weight can go up but you can spread it between the two bikes. If they're all the same, you probably need a bungee cord to give it a locking.

INTERVIEWER: But I guess if you have two people, I guess it won't be too hard having it side by side. I think it's achievable. If it's one person it will be a problem. I guess I need to look again at their individual needs and how much they need to carry. Just because one needs just a bag, or the other need an extra wheel and such, doesn't mean they can increase the load, by just having extra space. What they want is to carry as much as they can get, but it doesn't mean it will be as much.
INTERVIEWEE: So it doesn't necessarily mean a lot of big size volume items. Plus they carry gas don't they?

INTERVIEWER: Yes in china, they can only carry two. They basically have steel framing and they carry two each time to deliver them (Even water bottles too). But they can only carry two or three. That's what I'm thinking, instead of one or two; they can carry more stuff either by stacking up or etc. It also depends on how big I want this to be.
INTERVIEWEE: If you do have two bottles with framing and more of them....what if you go through an alleyway?

INTERVIEWER: Yeah it's the problem...it's going to be restricting.
INTERVIEWEE: I guess you need to go back to number 5 in the end.

INTERVIEWER: I guess we also can look at the time of year I think that's what I need to look at. What they need it for anyway. For instance from back home they have cold water bottle. They cook them and they carry 20 to 25 bottles to carry. Now they say that they can carry 60 bottles, but can they sell them all? Or does that mean they have to travel further to sell 60 bottles. This is why I thought allowing them to carry more does not mean they have to. So that's why I think 2 bikes together are good for farming. It is mostly to cut down their traveling time.
INTERVIEWEE: Because if you do have that system, sometimes they won't even get used. So if they have two bikes, one can get borrowed and get doubled up with extra wheel so they're stable. If it's big area then it won't be a problem, but if small are like house to house. And one person can take it there and come back and they can also swap and do another trip. Do they carry long stuff with them?

INTERVIEWER: It really depends
INTERVIEWEE: I guess if you have it in a system like this, having a plank.

INTERVIEWER: But steering will be quite hard. The idea of this is basically to create more freedom to carry more stuff and also to be able to ride it. Because at the moment they use it as a push trolley and walk with them rather than riding them like a proper bicycle. Looking more into what's important on the usability of it and trying to find balance and not sort of destroying the bicycle in the process
INTERVIEWEE: I guess it comes down to the wheel really. The wheel can carry more than they can carry by hand.

INTERVIEWER: This is good; I think we have quite a few points to look at further. Thank you for your time.

Appendix G.2

Interview transcript of Expert no.2 (October 8th, 2009)

Transcript interview: Expert no.2 (Industrial designer, researcher and developer)
Auckland , New Zealand , October 8, 2009

INTERVIEWER: Yeah, so the main thing now is about the usability and functionality of it. So, the question that I would like to ask you since you has seen this is whether you think that this is the right way to improve their human power transportation? By looking at the capably of what they can carry, the more they can carry the better? Is that an improvement in your opinion? Because, bicycle has been around since 1850s and it hasn't change for a reason. Because everything has been done, and its more about the mechanical part that changed through the years. The bicycle themselves didn't change. One person or two persons max. But bicycles are never designed as a working horse. Because it's so practical and cheap, you don't need gasoline and stuff. For lower income people, this is the best transport they have. So then this is the reason why I'm designing something they can use. So they can carry their kids, their stock/animals, items and such, so now I'm looking at their functionality of it.
INTERVIEWEE: Increasing the functionality is a good thing I think for bicycles. Yeah, I think it's good.

INTERVIEWER: But can you see any flaws in it? Problems that may have come across?
INTERVIEWEE: Depends on what it's for exactly. You've given me a variety of ideas for different purposes. So if you're trying to incorporate a whole lot of functionalities onto one system, then I see that this one is more beneficial. I see here about 11 or 12 different systems, if you can combine them into modular systems would be better. I mean, for the ambulance type one would be quite specific and it needs to be, I mean you don't have many ambulances around.

INTERVIEWER: I think one thing I forgot to mention to you actually one part of it I'm trying to explore is the specific needs for the midwives, ambulance, fire engine, doctors, so there's not so much on farmers or fruit sellers and such. It's more specific.
INTERVIEWEE: Yea, some of these are more suitable for farmers to transfers harvest goods, and there are a few different ideas on that kind of occupation and you got some specific kinds like health and such.

INTERVIEWER: I guess what I'm trying to see is how much I can push these ideas. By coming up with different systems, I'm actually going wide at the moment by coming up with different systems, but now I come up to a point where I have to choose or else I won't finish this project, So now I'm starting to look at some solutions. If I'm going to narrow it down again to a fewer number, then I need to be able to say which one is more beneficial and which ones are not. Several of them are similar because even though the mechanical are different, but they all work for the same purpose. So I have to be able to do like what you say which is combining them to come up with one that encompass the most use.
INTERVIEWEE: Yeah I think the more use of it I think is the way to go about it. Because you would help a lot more people. If that's what your aiming for too. So maybe you need to look at what industries is most popular in whatever country you're doing it on. I guess harvesting goods type things are most common

INTERVIEWER: I think the lower income people are mostly around the labour area. I think the better ones are the ones that work on the land but the others just work around the land so they get paid to harvest. And of course you got the tradesman who comes in and bought the stuff and take it to the market, but still in harvest time, they need to take the produce to the storage and such.
INTERVIEWEE: So, who would own the bikes? Would it be the farmers themselves? Or do they rent the bikes?

INTERVIEWER: I think they all got their own transport, most of them have bicycles. This is the reason why this is based on older bicycles rather than new bicycles, because they only use old bicycles which use the steel that people use now for the airplane industries. They're very strong back then, because they're meant to last. They can't make it weak and cheap, so they have to make it strong and built to last, but now bicycles are not for that. That why bikes these days can be more specifics such as BMX and such. So, they only use the old ones because they're strong and they think they can hold up to 400kg. Where the new bicycles are will collapse after 200kgs. Another point that I'm trying to make is that for me to ask them to demolish their bicycles and for me to modify them would be the same as me demolishing my cars to modify. For me I think it might not be the way to go, because to them bicycles are very important to them and they're a very precious item. Without it, they won't have proper transport; so, now I'm looking at a system where they can attach it onto their bikes when they need it or they can modify it depending on their needs and the time of years. They've been modifying bicycles, but they always come down to the limitation of resources they have, so they just slap it as long as they're practical (not necessarily well made). Just bits and pieces tied up, so not specifically designed for it.
INTERVIEWEE: I think that's where your connection comes to play. Maybe they help assemble attachment they have onto their existing bikes. They wouldn't mind making it out of anything but they will use bamboo or something onto it, then it will be more precious because its history. So, the system that you're trying to build for them would be somewhat made out of those materials but it needs to go together quite well by using your modular system. I think the more varieties of users that could use your system would make it look more attractive and it's going to be more applicable for different people. So by giving them a lot of options to create things for them, but maybe they can create their own ones, and having that flexibility would be quite good. Especially in those types of countries, where they have bamboos and such. I think that will be a key thing.

INTERVIEWER: That's actually a good point, to give them the system so they can build their own stuff, just like lego and such.
INTERVIEWEE: Yea and they can use their local materials, but you have the systems and they would look at it and think it 'oh this is much easier'.

INTERVIEWER: I guess they have the basic set ups
INTERVIEWEE: Yeah, and you have suggestions for them on how to maximize it.
INTERVIEWER: Out of 1 to 11, which one do you think have more potential than others? If you have to choose 3 of them to develop, which ones would you choose?
INTERVIEWEE: I really like the idea of the fold to nothing.

INTERVIEWER: So number 9, 8 and number 3. Number 6 is quite similar too.
INTERVIEWEE: Yea, I like those types of things because I would normally carry stuff there and at the back too because it would be more efficient. So, I think it would be good to have a system that you could carry away.

INTERVIEWER: I think that's where I'm getting at the moment. It looks fun like games and such but is that practical?
INTERVIEWEE: Yeah, it's really good at one stage, but would they go through all that effort to pack it away when they finish or would that be too annoying? Also, if you're at the windy area would that be a problem? From experience, it is hard to ride against the wind especially when you carry lots of stuff with you. So I'm guessing if you have lots of stuff, you would want to have more support and I think in number 4, this idea comes to play.

INTERVIEWER: So you think wheels will be quite essential for big loads to stabilize?

INTERVIEWEE: Yeah, it depends on how big the load is. If you have a big load, you don't want to be thinking on how you balance it all the time, because you need to focus on the power.

INTERVIEWER: Another problem is the fact that it becomes a working horse for them. They try to maximize the use of them so they put as much stuff as they can and push/walk the bike because there's no space for them to ride. So I'm looking for a way that they can ride it, because that is what bikes are essential for. (Transport rather than wheel barrow). For me that am part of the improvement I'm trying to make for these people. At the end of the day it is about how productive it could help them.
INTERVIEWEE: I think with the load on your rear wheel...would it be better in the front? Would it make a difference? If you're going down the hill with loads on the back, it would be fine, but if you're going uphill, you don't want to pedal up the hill. You're better off pushing it. Maybe you have to accept that and assist that kind of function.

INTERVIEWER: Yeah, that's why we have extra wheels to balance it up. That's the most logical thing, is to have extra wheel. But they told me that they would get penalized because they're considered as trailer. I will go back and make sure about this problem. What is the down side of this that you can see? My dilemma is trying to actually provide them with personalization. The two people I came across with told me they move from one village to another depending on the harvest time, so what I want to do is to help them to load the rice to the truck to taken to town. They get paid very little, but the biggest they allowed to picking up the rice that has fallen onto the ground. When they collect it together with dirt and such, they can get up to 200 kg to take back home and sell directly in the village. It depends on what time of the year; they have to ride very far away from home. It might take those 4 hours to get to the place, but it might take double the time to get back home due to the load. So I may be able to provide them with the option of 400kgs but I don't think they will be able to collect that much.
INTERVIEWEE: Yeah, it would probably be too much for them.

INTERVIEWER: So now I'm looking for where the balance lies. I can provide them with large space, but do they need it?
INTERVIEWEE: Realistically what people are capable of doing? We do that at work as well. How many people can do these jobs and how will you be able to manage the time and cost. So with bicycle, if they have to push it all the time, they will not be able to get back on time because of too much items.

INTERVIEWER: Yeah, basically they can store up to 400kgs by loading them up to their seats and to the frames, so the bicycles are no longer ride able.
INTERVIEWEE: I think I like 2 too. The weight distribution looks more even.

INTERVIEWER: Basically, I'm looking at the things that can mix and match. That's what I'm looking after at the moment.
INTERVIEWEE: So in Indonesia, how many people in farms are they?

INTERVIEWER: I would say a majority 60% of populations, because unless you give them opportunities in the cities, they need to go back to farms and especially in the islands. This is the reason why motorbike may not be suitable for them because given that they have to fix them engine and such is quite complicated and they don't read and write so it will be a problem unlike bicycles. Is there any other way you think I should do this? Any room to improve it in any way? Which one do you think could be the biggest problem for the people to manage?

INTERVIEWEE: I'm not too sure about these things too, if they were open mesh type of scenario it will be better, so it can flow through it. Probably, material wise for a wind to pass through it so it doesn't become an obstacle.

INTERVIEWER: Number 8 is looking at canvas or flex? I'm not sure if it will do it but I'm looking at what they can use and produce, so they don't need to rely on the people in the city to provide them. When they need it, they can get it or make it themselves or through craftsmen. I guess it has to be a material where the wind flows instead of a sail kind.
INTERVIEWEE: Yeah because a sail could work for you or propel you at the same time.

INTERVIEWER: Yeah it could be a problem. Since you use bicycles, what kind of things do you see as problems? So then I can avoid it.
INTERVIEWEE: Keeping the pedals clear would be fundamental and it depends if they move in to traffic as well. Because it will need to be compact like if you go to town and such. It needs to be robust and rigid construction wise.

INTERVIEWER: That's a good point; the more maintenance means more cost for them. This is why I am looking at these systems and the simplest ones may work the best.
INTERVIEWEE: Maybe when it is closed down like that, you can carry people at the back like an extra seat. I could imagine that you could sit on that.

INTERVIEWER: So when they are not carrying goods, they can carry people as well.
INTERVIEWEE: Yeah, and maybe they can sit there too while the other side can be for goods. Maybe it needs to be detached?

INTERVIEWER: I am actually thinking of something they can take off when they're not in use too. This is something that I am trying to focus and nail on now.
INTERVIEWEE: Well, if that comes into play, then maybe you don't need to have it so modular. So you can just chuck it on and of, but that doesn't always mean that it's what they want to do. If you load it all on and load it all off and leave is so you can beat the traffic to go home then the folding one would be quite good. If you want to go out at night too, you might want to take it off and make it look more flashy and such. I suppose you don't want to get stolen either. If it looks too flashy, then it will be more desirable.

INTERVIEWER: Yeah, making it desirable is one thing, but also making it too desirable is another.
INTERVIEWEE: But if you do make it of local materials, then people would think I can make that too. It makes people comes back to the same level again. Getting that balance would be a good idea, not to outclass you too. It has to be somewhat in the social level.

INTERVIEWER: Yeah that's a good point.
INTERVIEWEE: Then, how easy would it be to create that much of system? It's got to be something they are not able.

INTERVIEWER: They can't, because they don't have the infrastructure. That's why I am actually looking at bamboos, even though they are now reading about it. It looks simple but not really that simple. They still need time and expertise about it. They have to be a certain amount of time when they can harvest the bamboo. Manipulation is one of the things I am working on to, well the main part is to be accessible to them which won't cost anything or cost cheaper so they can sell it. So hopefully they don't need a manufacturing process. Because it will then became unfriendly to the environment. The only thing I am still concerned of is to cast it, will need some high temperature energy. But on the other hand, maybe the cut up bamboo itself after they trim it, they can use as an energy source. Because bamboo charcoal is the best charcoal they have around because they last long.

Maybe that's another part that I can look at, because they're not going to cut it and then get it the exact right size and shape; Which means there will be lots of excess, so maybe we can use that to power up the casting heat system.
INTERVIEWEE: Can your system be flexible?

INTERVIEWER: I don't actually want it to dictate myself to the actual material. What kind of flexible are you thinking about? Like rubber?
INTERVIEWEE: No, like that it can expand? Or spring? Elastic? To bind them together instead of being fixed.

INTERVIEWER: Why?
INTERVIEWEE: Because it will match whatever materials they use like the shaft they need to create the structure with. It's more flexible to use around that material.

INTERVIEWER: Do you think it won't fit?
INTERVIEWEE: Yeah, if it won't fit, then you can adjust the diameter and such.

INTERVIEWER: One part of the research is actually the manipulation of the bamboo itself. I am hoping that I can actually do the experiment before March because the bamboo will come out sometime after this month, and the Japanese already done this for for their housing. So, what they did is use plank and cover up while forcing the bamboo to grow square than round. So based on that, if you get a tube and chop it and put it on to bamboo, the bamboo that grows will be of the right size. But then the further I go is harder to make the decision on which one I want? And which system is better? Because, my thinking is that the actual parts of the bamboo, rather than straight it could have an angle on it. Because in the old age they tied the bamboo up so they will grow on an angle.
INTERVIEWEE: Yeah, and it means you have to train people for it, and they will be the controllers of the technology, so they wont become free anymore.

INTERVIEWER: But I am actually thinking of putting capping on the bamboo, by putting that caps, people can just go the back and chop it off and it will be the piece they use. Because some type of bamboos can grow up to one meter a day. So if you want a certain part then you can get it. So I started to actually think of the ways to grow them so they can grow each part differently. But I guess, I am trying to find out whether it will work or not, and calculate whether it's the simplest solution, because by all means, usually the simplest solution is the best, but the simple needs to be functional too. If you got just simple and not functional than it's not the way to go.
INTERVIEWEE: Yeah, simple in a way that it actually work, but simple in a way that you got it together initially and maybe you got to look at the life cycle of the parts too I suppose.

INTERVIEWER: True, well, that's actually the argument, which is whether having steel where it actually lasts forever or bamboo that you have to fix every 2 years or 5 years. Keeping in mind that bamboos are very strong.
INTERVIEWEE: Yea, but under certain conditions, does it weigh more? Under the sun, rain, and would it snap half way through?

INTERVIEWER: As we said, bamboo doesn't bend like steel and they shatter. If they shatter between the legs than it would cause more damage than steel.
INTERVIEWEE: Yea, because in examples of when they use it in furniture and scat folding. So, scat folding is a temporary structure and they use it quite a lot; but after the building is done they do away with it pretty much probably because they're not good for it for the second time so you get rid of it. For house and stuff, it's away from environment

(sun &rain) so it doesn't deteriorate as quick. But for a bike, since you use it every day, you come across of it deteriorating.

INTERVIEWER: Bamboos are actually something that they know quite well, because they build the houses with it and such.
INTERVIEWEE: But these are internal structure aren't they? Or are they external too?
INTERVIEWER: No, they're external too. I'm looking at different way of preserving it without actually using chemical. I'm trying to get away from epoxy and trying to use that fat on the walls (lanoline). Because lanoline don't actually dries out, so if you use that, it becomes water resistant.

INTERVIEWEE: Is it UV protection? Oh yeah, because that's what they use for sunscreens. I think there's some chemistry in it actually.

INTERVIEWER: I guess in all products with chemicals, there is a certain degree of chemistry in it, but I'm trying to eliminate as much process as possible, trying to use as less energy resources. And hopefully since they came from nature, then it will be biodegradable.
INTERVIEWEE: Yeah, but I guess these people wants the object to be robust and not have much to do with it. They probably want to just put as much stuff on it as possible without thinking that it only has 6 months to live and such. So I think, if you're telling me that these bikes are made out of good material then they wouldn't have second guessed the integrity of the structure of the bike, but to have that assured in the new modular system is something else. If it's made out of natural material, then they want the same kind of guarantee because it's their livelihood that depends on it. So, I would assume they want to do things once unless they change career. I guess that's what this guy's bike is for. Just for one or two different functions, so it's probably quite specific.

INTERVIEWER: So you're saying that personalized can only do so much?
INTERVIEWEE: Well it can do probably the things they want it to be. If they got fruits then it can be designed a certain way, if they got food then a certain way, if does a lot of rice then it can be designed in a certain way and in the end it will just collapse again which is a really good thing, but I don't know if you want to add more and more function to it. It can only be a couple of functions and I think expanding and coming down would be great. Maybe he can have medium range (like half as much items) to the maximum, maybe not 400 kg, maybe just 250 or 300 maximum. Because I think 400 is too much. Because I guess if you don't have as much loads, I guess you want it to be smaller and have it to be more functional and faster, so I guess you can work from one side and work from there.

INTERVIEWER: Stability wise I think you have to work both functions or else it's going to be hard for them.
INTERVIEWEE: Yeah, I guess you have a maximum size and you can determine that and for whatever the work purposes they can have less load on them, so they can collapse and be easier to use for the less. So it becomes specific needs, but I guess it also depends as well, because one guy would do bamboo for one week and then the next would do something else and such.

INTERVIEWER: Well, some of them are actually movers like a taxi. People pay them to carry the items. So their job is like a taxi driver but also like a truck, so it could be almost anything. So they're probably the ones that need it the most. I think it's easy for the hawkers that are selling veggies and such because they know how much they can sell and such. So they wouldn't carry the stuff that they can't sell. So that's probably why it's going to be important to have it bigger or smaller so they can adjust. I'm guessing the movers are the ones that are going to be most helpful the most. Because, farmers and such

knows their limits but movers may not. Perhaps the only thing is making it attachable and detachable so the bike can still be used as a bike to ride.
INTERVIEWEE: I see in some of these guys that they're using it a certain way and that's not possible for the others.

INTERVIEWER: Yeah, so if you use a bag or something, you can't have a big thing in it, because it's not flexible enough. But if you have some sort of deck, then it would be more flexible to chuck things on it.
INTERVIEWEE: Yeah, I guess that's where it fits in better. You can have a structural deck on top like that but still have bags underneath. And when it collapses to nothing again, then you can use it as a bike.

INTERVIEWER: Yea, that's why I'm actually looking at using materials, because they just collapse to nothing.
INTERVIEWEE: Yeah that's good, because then if he wants to fix a fence for his house, then he can line it up along the deck sort thing.

INTERVIEWER: That's number 10.
INTERVIEWEE: Yeah number 10 functionality is good.

INTERVIEWER: Yeah, because you will be surprised on how they use the bicycles. Because I took a lot of pictures and they're unbelievable. Starting from the very basic likes using it as carts, but they become a kitchen in the end, you see that's crazy, you have Honda civic on top of that bike. This one is an outlaw in my country and it's called the 'becak', because they're such menace, because they don't have licence and they just hit cars and such. This one is the new thing; they just came out and became an entertainment. You see this one is really full and that's why they can't ride it. They just walk with it, that's why I want to actually make it ride able. This one is from Ghana and this one is from china.
INTERVIEWEE: So, you're saying that they also use three wheels?

INTERVIEWER: Yeah, but then again it's something I need to confirm. My point is actually not if you change it to three wheels, they're not a bicycle anymore. Would they be willing to do that? Perhaps looking at the bicycles users being the lower income in town?
INTERVIEWEE: Ah I see.
Slides show of bicycle pic taken in Indonesia was shown to Interviewee

INTERVIEWER: So, you can tell that there is no consistency in the use of their bicycles. They just use what they can find. Then you got a system like this where it's just an entertainment. So, they change their bicycles to do a specific task, so they're no longer just transportation.
INTERVIEWEE: Well then, if it is for around town a little bit more, maybe something like this would be alright. Such as for food and such (still collapsible).

INTERVIEWER: So these ones with basket? They're homemade.
INTERVIEWEE: Yeah, it would be quite good.

INTERVIEWER: Yeah well I guess now I'm trying to find out whether it's the right direction. This one is quite interesting, this guy is a typical farmer that collects rice from the ground, and they carry sickles and such. They're not specifically designed for that but they found a way to get around that.
INTERVIEWEE: I think if you're going to go with farming, it's not like they're going to do a lot of thing with their bikes. The guys in town would want it to look smarter but the guys

outside of town wouldn't even care as long as it does the job, and maybe modularity would be important to them.

INTERVIEWER: I think modularity is so big, because it allows them to actually do these things, but it's not as to worry about changing it, they can just have it as one thing.
INTERVIEWEE: I think people who are concern about it, would be the people in the city when they go for groceries and such. But, bamboo might not be an issue. But it doesn't need to be steel either, maybe it can be a material that's used around town which are cheap.

INTERVIEWER: They can use rods and just weld it.
INTERVIEWEE: Well maybe even plastic pipes (plumbing pipes)

INTERVIEWER: Yeah depending on how easy it is to obtain the materials. That's why I chose bamboo, because they don't have to rely on the supplier so much. They just look at the material that's available without costing them arm or leg.
INTERVIEWEE: What are these things?

INTERVIEWER: Those are extra suspensions. All old bicycles have that, but not new ones. The old ones are stronger. When I talked to people in the bicycle company, they said it has something to do with the angle of the fork so today's fork is almost straight. So it's like some sort of double suspension.
INTERVIEWEE: Interesting.

INTERVIEWER: It becomes an expensive item now, it becomes collectable item. This one they're selling cold water, what they're actually selling is the ice in the bucket. So they sell it to the farmers. But they work the whole day carrying 50 bottles. How much are they going to make? That's why I'm quite amazed, is that the only amount they can carry or is it not enough space to carry?
INTERVIEWEE: It's amazing how people live.
INTERVIEWER: Yeah, we take things for granted.
INTERVIEWEE: Yeah for sure. I LOVE NEW ZEALAND. When I went to Taiwan I saw it and I thought that amazing how they work. I guess that's why I went hard out with my own projects.

INTERVIEWER: Yeah, in NZ we have infrastructure. That's why we pay taxes and stuff. But these people in Indonesia don't have a choice. You can just imagine that their kids will be doing the same thing.
INTERVIEWEE: Yeah, they can't find a way out.

INTERVIEWER: So yeah, it's a vicious circle.

Appendix G.3

Interview transcript of Expert no.3 (October 11th, 2009)

Transcript interview: Expert no.3 (former European motorcycle designer)
Auckland , New Zealand , October 11, 2009

INTERVIEWER: I've talked to you about the paper which is about providing people with the more functional human transportation, and it's not saying bicycles or anything. And now I'm looking at bicycles because that's the only thing they have, and it's really important because their livelihood really depend on it. Now if I do ask them to chop their bicycles to bits and modify them, would they do it?
INTERVIEWEE: I guess not

INTERVIEWER: No, that's why I look at it a little bit silly now, because now when I look at it, it's still a bicycle. The reason why they have the old bicycle is really simple, because they can't use the new bicycles because they don't have the same strength. These are based on the old bicycles with the big wheels, because the reason is that they can hold a good amount of weight up to 400Kg. So now it made me think, to improve the functionality and usability of this human transport, maybe changing a bicycle a good option. That's why we're here now; I would like to ask your opinion on it.
INTERVIEWEE: I think first thing is that I wouldn't chop the bike into pieces for sure. I think one of the big problems is actually that not all bikes are the same; it's always the problem of hiding attachments points which fits all the different sizes and geometry points or so. Once you solve this, you can find the bikes with the same area on the other hand you can react with your product with a different point, so that should be all right.

INTERVIEWER: At the moment, these models are the places where it could go.
INTERVIEWEE: Yeah, it seems it's the consistent point of underneath the saddle.

INTERVIEWER: But at the moment it should be somewhere lower because it has been proven to be more stable and that way they can carry more stuff.
INTERVIEWEE: Actually, if you use the diamond shape at least you know that at some points they would be the same, so you see most of them you use the axel to become one point of them where the other one is underneath the saddle somewhere.

INTERVIEWER: I'm actually looking at the main part where I can attach it to, because they actually already have the ones where the axels are the attachment point, and you can actually extend it.
INTERVIEWEE: Ideally the solution would have one or two pieces that join everything together. So, the more joints you have, the more difficult it will become. If you have 6 joints and you try to figure out which ones go where, then it will be a nightmare.

INTERVIEWER: And don't forget that these people will only do it if they can see the reason of doing it, because they need to feed their family.
INTERVIEWEE: I mean in general some people can't see maps and so. So, building houses and such, they can't see the maps on how to build it. And if you give them instructions of maps that you need certain bamboos, and then certain length, they might not be able to do it. So it needs to be very self explanatory, so you see it and you know where it goes. Maybe it's interesting to look at IKEA, because what you do is you buy this thing, you need to build it without looking at the plan. If it gets really complicated, you have to follow the plan, but you need to concentrate. So therefore, the less parts would be the better. So if you have a part that's a certain length and the other is different of 5cm, than it would be extremely hard for them, and if its bamboo how can you mark them? Unless you give them some sort of paper template or something so they can just start measuring them so they know which piece is for which. So, you can put it on the floor and you see piece by piece and then you can put them all together afterwards. Or maybe they're quite the handy people so they don't have a problem with it.

INTERVIEWER: Yeah, I think that's another thing to question is that, would they keep changing it or just do one because they know what they want to do.
INTERVIEWEE: I could imagine they would change it, because I only have an experience from Africa, and they change their all the time. They keep on modifying it, if they break they will fix it with wires or tape or parts from cans and such.

INTERVIEWER: That's the thing, based on my research, it shows that they are modifying. They've been modifying from the beginning, but they are limited to the amount of resources available. This is why I came to a conclusion maybe that this is the way to do it. By giving them transportation of something simple. Like, natural resources would not cost anything. At this stage I'm looking at it and it looks like it's the way to do it.
INTERVIEWEE: If you're only using straight pieces then it would probably be easier. They don't have to bend or anything. It seems like what you're saying is that, they're leaving at around 5 or 4 in the morning and come back at 10, so when do they have time to look after the growth and such.

INTERVIEWER: That's probably why I'm mentioning it to the people who go the people who actually do this.
INTERVIEWEE: So some people would do this job?

INTERVIEWER: Yeah , I would think this can becomes their job as the supplier.
INTERVIEWEE: I guess at this case, if you're thinking of bending the material, then you also need to take account of the huge tolerances they have. I bet it's pretty hard to grow everything in the same position you want it to be. I mean even metal has some tolerances. So, maybe you have to consider that. If you have tension on it and use it as is, could probably be easier. But to have everything in the particular position and chop it off at the particular place then....

INTERVIEWER: Yeah, I don't think I'm going to go as far complex shape, and I need to prove it that it can be done too.
INTERVIEWEE: I think when I look at these things; it looks like you have many layers next to each other. I think it's something that ideally is on the same level, I mean I know that it's the same as scat folding and stuff like that by having it next to each other, put a wrap around it. I know that this is only model making, but it can be a way of simplifying it, and make it less complex.
INTERVIEWER: It definitely needs to be simpler. I need to make sure that the principle would work.
INTERVIEWEE: Yeah, I understand that and it's just a model making that's in place, but I realized the more layers it has, the harder it becomes. So maybe you need to restrict yourself to two layers only or something like that. Talk about the usability of it, I think the narrower the better.

INTERVIEWER: Considering the environment they have to negotiate with.
INTERVIEWEE: Yeah.

INTERVIEWER: So you think actually, this is actually going to improve what they have in terms of transportation?
INTERVIEWEE: I think yes, maybe the problem is that the problem is to define the items they will carry in terms of your concepts and such. Definitely need to know better on what they carry so I can evaluate it and makes more sense. But I think by being able to carry more stuff on their bike could improve their transportation.

INTERVIEWER: This is the reason of why I'm looking at one being generic enough so everybody can get benefit from it. Some are actually overlapping with similar concepts but I'm actually looking more at what can be achieved whether the functionality can be the same.
INTERVIEWEE: So what kind of stuff do you consider them to carry?

INTERVIEWER: Well they're always different, but the market I'm looking for is more about one is farmers so they need it on harvest time and also typical thing they also use it for kids to school and such. The second thing is hawkers, they're the ones that sells the produce; they're the one that buys the produce from farms and go out and sell it to the market.
INTERVIEWEE: So they carry the same stuff?

INTERVIEWER: Yeah, but the thing is that the bicycles become the shop.
INTERVIEWEE: I see

INTERVIEWER: The third is actually the movers. They're the ones who carry the most stuff. They carry from nothing to everything. Such as one picture I took was the bike carrying the chassis of a Honda Civic, so the car was on top of the bike.
INTERVIEWEE: Like an ant carrying the massive food.

INTERVIEWER: Yeah, that's the heavy one, so those three are the most common ones.
INTERVIEWEE: So what kind of stuff they carry? Food, clothes?

INTERVIEWER: Water, tools, etc.
INTERVIEWEE: Do they wear backpacks or anything like that?

INTERVIEWER: No
INTERVIEWEE: So backpack could help, but they don't use it? Is it too expensive to them?

INTERVIEWER: They didn't mention that to me, but I will think about it. I haven't seen one carrying backpack.
INTERVIEWEE: I mean imagine if they have backpack, they can carry their lunch, clothes and all.

INTERVIEWER: Normally the wives would carry the lunch with the baskets, and they will bring it to the farm. One of the study cases is the people who sell cold water. So they basically use the recycled water, cook it and sell it. So they go to the farms and sell waters. But the thing is that they only carry about...30 to 50 bottles and they really cost peanuts. The distance is about 2 hours away from villages trying to sell little money, I just don't get it.
INTERVIEWEE: Yeah you will be surprised on that.

INTERVIEWER: Yeah and the thing is that they use the 20 litres paint bucket as an ice carrier and put the bottles of water in there and close the lid so they can carry it.
INTERVIEWEE: So in general, are these the build on solutions? Did you think of trailer?

INTERVIEWER: Well, the thing is that I need to go back and make sure about this thing and ask the authorities. When I went back last time, they only walk their bikes because there's no space for sitting down since the whole bike is full of items. So I asked them why not use a trailer? They said they will get taxed by the government. I heard this from two people there, so I need to go back and get more confirmation.

INTERVIEWEE: Yeah, I mean this is the best option, because it carries the amount of stuff, then you can unhook it and such. So number 4 is quite good.

INTERVIEWER: Yea, it seems like the best solution in regards to the trailer. And number 5 I don't think it's constitute of being a trailer or not.
INTERVIEWEE: I mean if I was to think of carrying lots of stuff then I would automatically think of extra wheel.

INTERVIEWER: Yeah it would be stable too.
INTERVIEWEE: I mean number 4 looks quite wide and it could be a problem I see. I guess you can narrow it down. Because if you look at it, being two bikes coming from opposite direction in narrow road then... it would be a problem.

INTERVIEWER: Yeah and the roads are only narrow enough for 1 person.
INTERVIEWEE: Number 5 I think is a really good solution, but it looks very complex. I don't know, maybe you can put less beams or something.

INTERVIEWER: The thing is that when you have things that slides, it will become complex.
INTERVIEWEE: Yeah the question is whether you need it sliding or not.

INTERVIEWER: Yeah, the thing is that customization is the important thing.
INTERVIEWEE: I mean if you fold this down, both sides then it would both be sliding yes?

INTERVIEWER: Yeah, I mean I would check it again with the rest and try to combine it. After this interview I would see which ones to take and try to work around it.
INTERVIEWEE: I mean, they could carry the biggest weight possible and more stable. I mean, I would wonder if these constructions here have a downside. If this has a fixed wheel and no pivot point, I think it would be hard to ride without the pivot.

INTERVIEWER: Yeah I think we need the pivot so it will be easier to ride.
INTERVIEWEE: Yeah and to think of the gravel road and such, so added another wheel would make it harder. If I look at modern bike trailers for long distance, they only now use 1 wheel for it. So this mono wheel is very good because it's very low complex. If you look at the complex ones, the most important thing in there is the joint.

INTERVIEWER: Yeah I looked at the joint and it's actually that again they're from the axels.
INTERVIEWEE: Yeah there is some German company with complex joints and then I saw this one with just a spring and that's it. A spring welded of two metal bars is simple and you can still control it. It is a really good design piece and used for a very expensive trailer kind of object.

INTERVIEWER: I want to show you this one (no.8) , I'm not saying it's my favorite; I just want to know what you think about it. By using material you can use it this way. And the frame too is simple to use, so if you have it on both sides, then it would be quite good.
INTERVIEWEE: Yeah I think that's one really good structure because it's very simple.

INTERVIEWER: Can you see any problem with it though?
INTERVIEWEE: If you use it like this it would be a problem, so you need it to be balance.

INTERVIEWER: Right here I'm actually looking at more items like for paddies and such.
INTERVIEWEE: I guess if you're looking at using material, it would be quite good because it may not be fully closed but it creates baskets which can be quite useful.

INTERVIEWER: Because this is going to be quite simple, but I could see it being a negative point too.
INTERVIEWEE: I think this mounting point here could be difficult to achieve. Because it has to be even. Actually you don't need that, if you have a triangle frame then that's it, you don't need most of this point.

INTERVIEWER: The only reason is that all of them have decks on top of them. So if they're not in use then they can be a seat for other passengers.
INTERVIEWEE: But here, you only need to lift it up so it goes above the tire line?
INTERVIEWER: Yeah it has to be, but it's only for the purpose of the model. The lower it is, the more stable it will get. This is probably by far one of the simplest of all. But it may not be good for it either.
INTERVIEWEE: What kind of fabric do you think you will use?

INTERVIEWER: I'm actually thinking of a natural woven bamboo or sheets; but I'm actually thinking of just hooking it up instead of doing it that way. Putting it this way it might wobble.
INTERVIEWEE: It will be even to be stable.

INTERVIEWER: This is why I think number 8 is quite interesting.
INTERVIEWEE: Yeah I do think that the textile solution is interesting because they offer you something different. You get more flexibility
.
INTERVIEWER: And they fold up into nothing.
INTERVIEWEE: Yeah, I think textile is better than having frames and such. So I think reduce it and make it simpler would be good.

INTERVIEWER: Yeah, I think number 3, 6 and number 7 are actually allowing you to be a bigger one. Still what I'm offering is just a deck so they can put their stuff.
INTERVIEWEE: So they also have the canvas to carry all their stuff too.

INTERVIEWER: Yeah. Number 9 is similar, but different pivot point.
INTERVIEWEE: Number 9 from a design point of view is a very nice solution. The transition is very nice. I could imagine that if you bring it to design competition then it would be a good because it gives a nice movement and such. So the transition of one shape to another is good.
INTERVIEWER: My concern is that if you have a basket and a box is that it then limits you to the amount of things you can put in there.
INTERVIEWEE: That's one thing, another thing is that each pivot point adds more complexity and it adds more problems which creates more failure too. So number 9 is definitely is one of which goes the high end solution area.

INTERVIEWER: Number 10 is similar but in a way I'm looking at the series of baskets. So you can still stack them up.
INTERVIEWEE: Yeah it seems like its more suitable for some dealers and such, but it's also limited on the amount of stuff you can put in there because of the space.

INTERVIEWER: But besides that, unlike number 9 they can stack up.
INTERVIEWEE: Either you have to give them the structure on top of the rear wheel to get them to point at the back.

INTERVIEWER: Number 11, I think it's too rigid. This is more for hawkers.
INTERVIEWEE: And it doesn't look as flexible too.

INTERVIEWER: Yeah, but the hawkers can separate their products, but it won't be as flexible.
INTERVIEWEE: Do you have to exclude all of them or can you give a blueprint of three solutions that can be done with the same joints.

INTERVIEWER: I think that's what I'm after.
INTERVIEWEE: Yeah because I think that number 11 being good display and 10 good for sales, and other can be good for moving stuff around.

INTERVIEWER: Number 1, if they're going to be under the sun and other weather all the time and they carry produce that can go very bad quick, it can be covered.
INTERVIEWEE: Having something that's not square would look better anyway. Because the one with square looks more dangerous, that's why the round solution looks better and it's a better design solutions. The curve is also functionality wise because it's safe and also saves you two joints. It's advantageous. I wonder if you can use the tension of this material you can make the structure sounder, because that will be a good strategy. Can you heat them?

INTERVIEWER: Heating them actually makes it tougher, because in Japan they're already using that technique.
INTERVIEWEE: But it won't be as flexible?

INTERVIEWER: Yea, that's the only problem. Number 2 is actually something to provide them to stack them up.
INTERVIEWEE: Number 2 looks difficult to handle. It looks too heavy.

INTERVIEWER: It is too rigid and too bulky.
INTERVIEWEE: The structure here, that is good, because the triangles give you a stable base, so you don't have to use the point over the wheel.

INTERVIEWER: So the thing is that I'm just looking at them and split them to different compartments and such.
INTERVIEWEE: Do you know how to maneuver something that's in the front? I always think that it's harder to do it instead of having something that's at the back.

INTERVIEWER: Yeah it is harder because they can't do a part turn, but the thing is that you can see what you have.
INTERVIEWEE: Yeah, that's right so you can see that nobody is snatching your stuff. You have more visible control in handling your items.

INTERVIEWER: Yea, the thing is actually there's a lot of double ups in concepts.
INTERVIEWEE: I think in the end it will be best to ask the people that will be using it, and get feedback from them because they will be able to eliminate some of the solutions.

INTERVIEWER: Well, I do need to integrate some of these solutions, because a lot of repetition could come up with different functions.
INTERVIEWEE: Yeah I guess a lot of them could result to more refined joints and structure and such. (What needs to be done?)

INTERVIEWER: Yeah this is the reason why I need to Indonesia to confirm them all.
INTERVIEWEE: Yeah, and I think they will have a really different view on it too. I mean they do have different approaches and such, I'm trying not to look at it in a designers point of view of aesthetics and such, but in the users point of view, but still I don't know how much they carry and I don't know a lot of things.

INTERVIEWER: Yeah, I mean I talked enough to them, interviewed enough, but their lives are so unpredictable, so it's hard to decide whether they will carry small thing or big thing. That's why I'm doing a series of both big and small.
INTERVIEWEE: The first thing I would do is too look whether the trailer is illegal and such, because if you find out about that, then you would be able to come up with different solutions to help these people.

INTERVIEWER: Yeah, that's why I'm going back to confirm it all, but I guess we all have to start somewhere. I realized that if you ask them what they want in the future and stuff like that, they won't be able to answer those kinds of questions. For them, their life is perfect already; they modify their bicycles to the purpose of their need, so doing something like this will go over their vision. So by doing something like this I can present them several options that they choose which ones better.
INTERVIEWEE: This one here, I wonder if you can join it here instead of here and there and there to make it stronger. Because with 2 triangles, it will be stronger rather than from here to here. I just think that attaching it directly to the bike will be harder than creating a joint for the bike.

INTERVIEWER: Yeah I think so too.
INTERVIEWEE: Yes, because they have to fit to different bikes, and different size of tubes. I guess it needs to be very flexible.

INTERVIEWER: Yeah I think that's what I'm trying to achieve here.
INTERVIEWEE: Yeah I think you will be looking in a line of some scat folding system or something like that.

INTERVIEWER: I think that's why I need a better picture, so I can go to Indonesia and show them what I'm looking for. I need to know what I want to achieve first.
INTERVIEWEE: Yeah, you do, as I was saying, if you know 3 different options to build from these, and you give it to them, they will eventually come up with different options. Maybe if they come up with better solutions, you can buy it from them and then add it to your booklet or some sort, so they can achieve money out of it too.

INTERVIEWER: Yeah that's a good point, and they're helping each other basically.
INTERVIEWEE: Yeah, so another generation could say that by adding another joint here, you can have this and this and such, so it could be better for your development.

INTERVIEWER: Yeah I think that's a good idea.
INTERVIEWEE: They won't be able to connect to internet to share to the rest of the world, but still.

INTERVIEWER: Yeah I guess it will go back to the chain supplier and they will sell the idea and such.
INTERVIEWEE: Yeah and I guess you can tell them that hey, each year we have competition and give out prizes for new invention and stuff. Maybe each different village has their own trademark design and such, so one village will have it working this way, and another have it working another way.

INTERVIEWER: Yeah it is definitely something to look at. They probably won't go very far, but I think it will be good in a sense that they will be helping each other.
INTERVIEWEE: Yeah or you can do something such as building the infrastructure for them, and they will supply the people with the goods and the people will buy it from them and the result will just go back to the business company which will spread the word. I don't

know what it's called but we have something of similar structure in Germany. I am sure they have these kinds of thing there already.

INTERVIEWER: Yes they do have a similar thing, but the thing now is to think whether they need another dependency for the people.
INTERVIEWEE: Yeah that is a bit of a problem.

INTERVIEWER: Yeah that's why I'm making it so they don't have to depend on anyone and basically just do it themselves, but at the same time they can increase their productivity.
INTERVIEWEE: If it's owned by the people then it wouldn't be a problem, whether corporate would be a problem.
INTERVIEWER: Yes, now out of all these 11 of them, which ones do you think would be most natural for this specific market?
INTERVIEWEE: I think something that has third wheel would do, maybe number 4 than 5. Number 8 has some sort of potential. I like number 9 functionality of it. For me it's difficult to pick because looking at the pictures and such, they seem to have a lot of different use of it and I think it's hard to say that- that is the one. I think its best doing a modular system instead of one. Maybe designing a good joint or a structure to begin with and what goes out from there could individually be different, and I still like the trailer but you need to make sure of that first.

INTERVIEWER: I think you brought a good point about having one wheel extension. What do you think of the people that work in the village? Because they are always work in pair. What do you think about making a system of putting two bikes together?
INTERVIEWEE: Well I know about the people who travel the world with bikes. What they did was put two of them together and raised a sail so they just sail all the way through. I think that's an interesting option, they're not general, but joining two together is a good option.
INTERVIEWER: Is it hard to steer?
INTERVIEWEE: They have to basically join the steering together and move them slightly, so I don't think it's that difficult. I think it's something you have to test with bicycles because you can't be too sure about it.

INTERVIEWER: There has been a suggestion, since they just walk with the bike, why not push it like a trolley?
INTERVIEWEE: Well it would be harder to steer wouldn't it.

INTERVIEWER: Yeah, I guess you will be then looking at forklift, where the back wheels are the one that steers.
INTERVIEWEE: I think in some of the picture you have here, you have a very interesting ways of stabilizing it such as the bungee cords and such, and I guess it can be something you integrate into the final design.

INTERVIEWER: Yeah, I think there are quite a few issues you raised today where I have to look more into later. I think in the end of the day I will have to bring it back and see myself. I think it will be interesting to see that if they have an option, would they take the biggest load they can carry or just the ones they need.
INTERVIEWEE: Yeah, for us I think we will go for the ones we just need.

INTERVIEWER: Yeah that's true.
INTERVIEWEE: And I do think that they will modify it. Because they use this as a professional tool, so they will modify it to suit their need. I mean that's something that I would do.

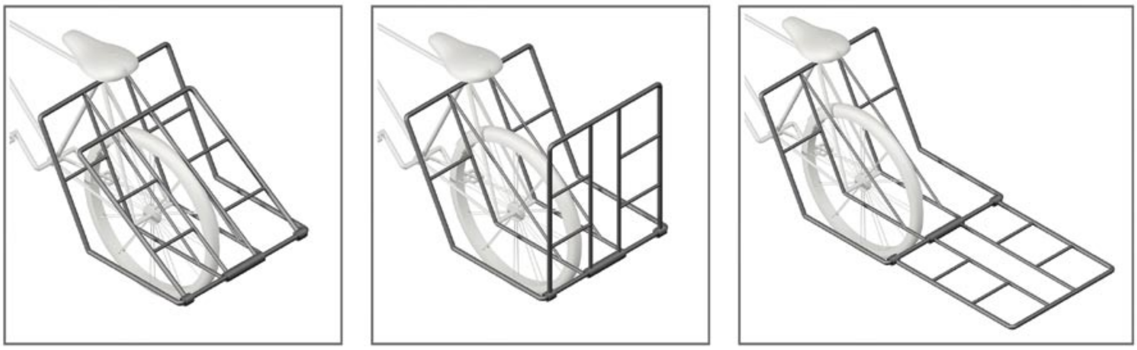
INTERVIEWER: Yeah, it will be interesting. Because I've asked them what they want, and what they need for them, but they said oh maybe the tires. And I asked whether that's all, and they replied yes. So they basically can compromise with what they have. They do tape stuff on it and such.
INTERVIEWEE: I would consider that as modification. If they start taping stuff on that, then it will be modification.

INTERVIEWER: Yes I agree. That's good. Thank you very much for your time.

Appendix H

CAD generated manual diagram of Greencycle Accessories

Concept No.1



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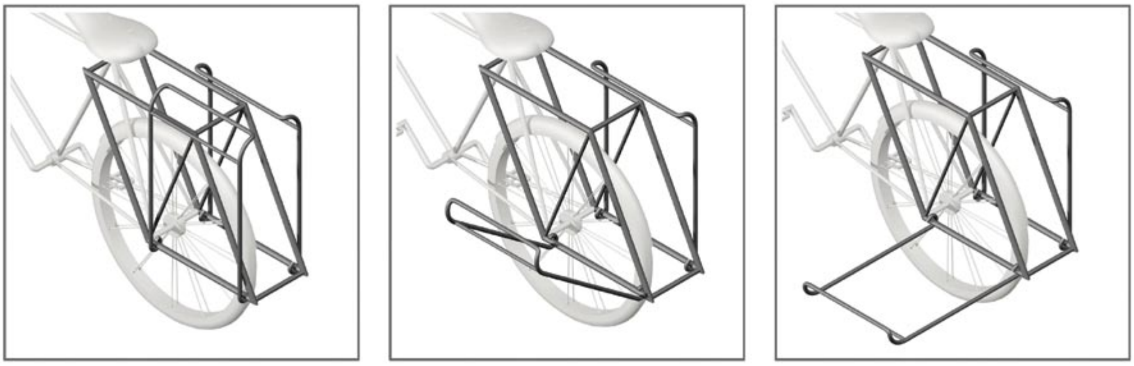


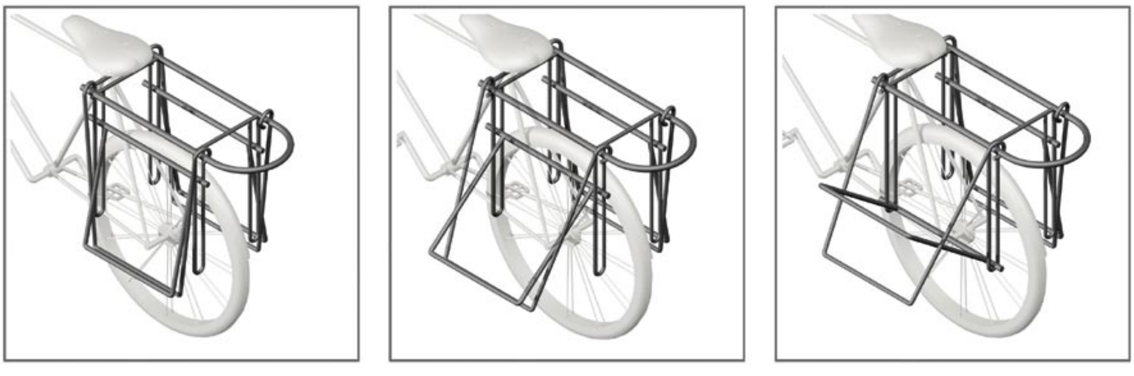
Concept No.3

Concept No.4

Concept No.5

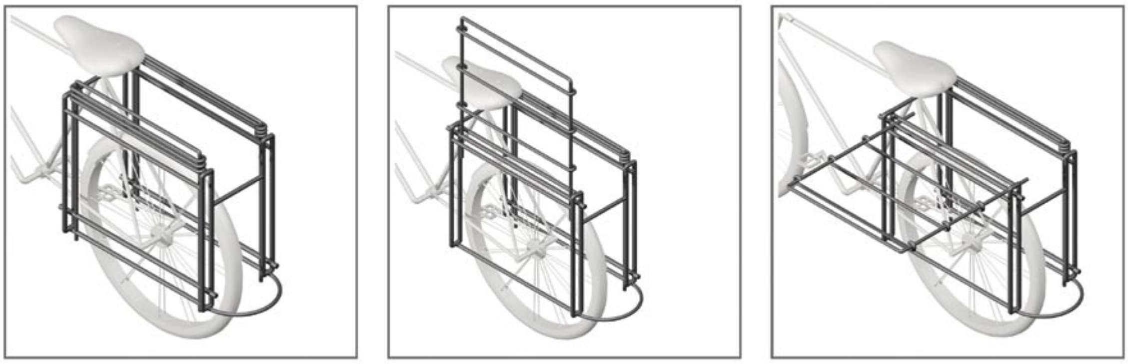
Concept No.6

Concept No.7



Concept No.8

Concept No.9



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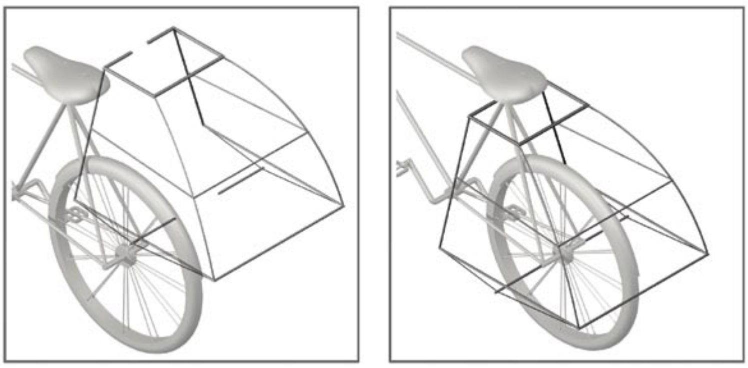

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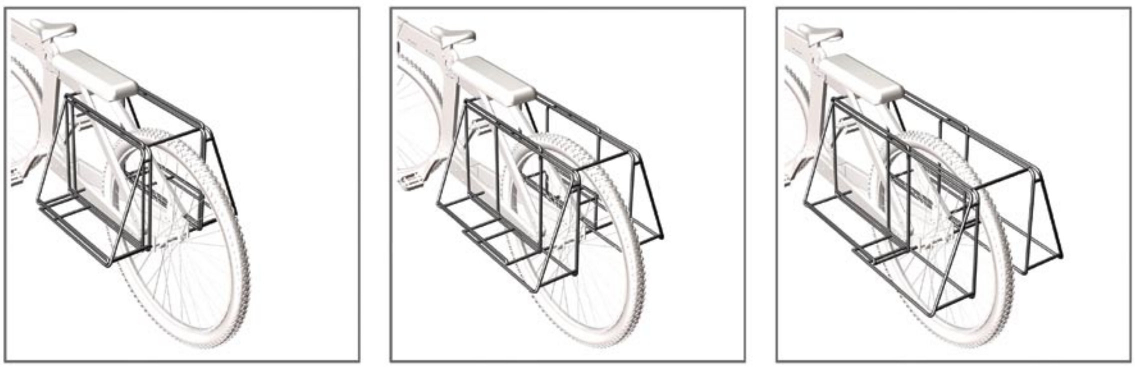

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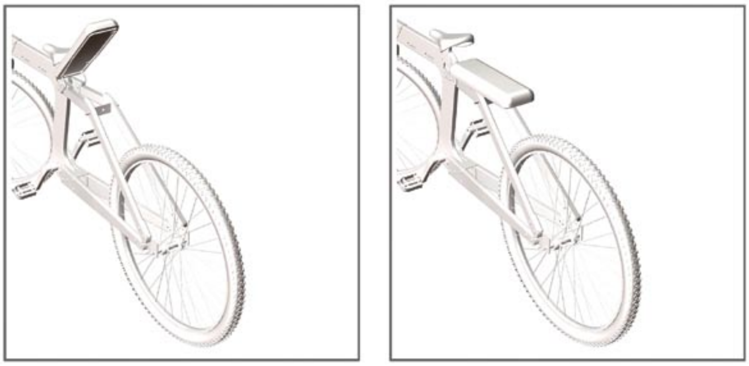

Concept No.13

Concept No.14

Concept No.15

Concept No.16

Fig 318. A Greencycle with the accessory

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